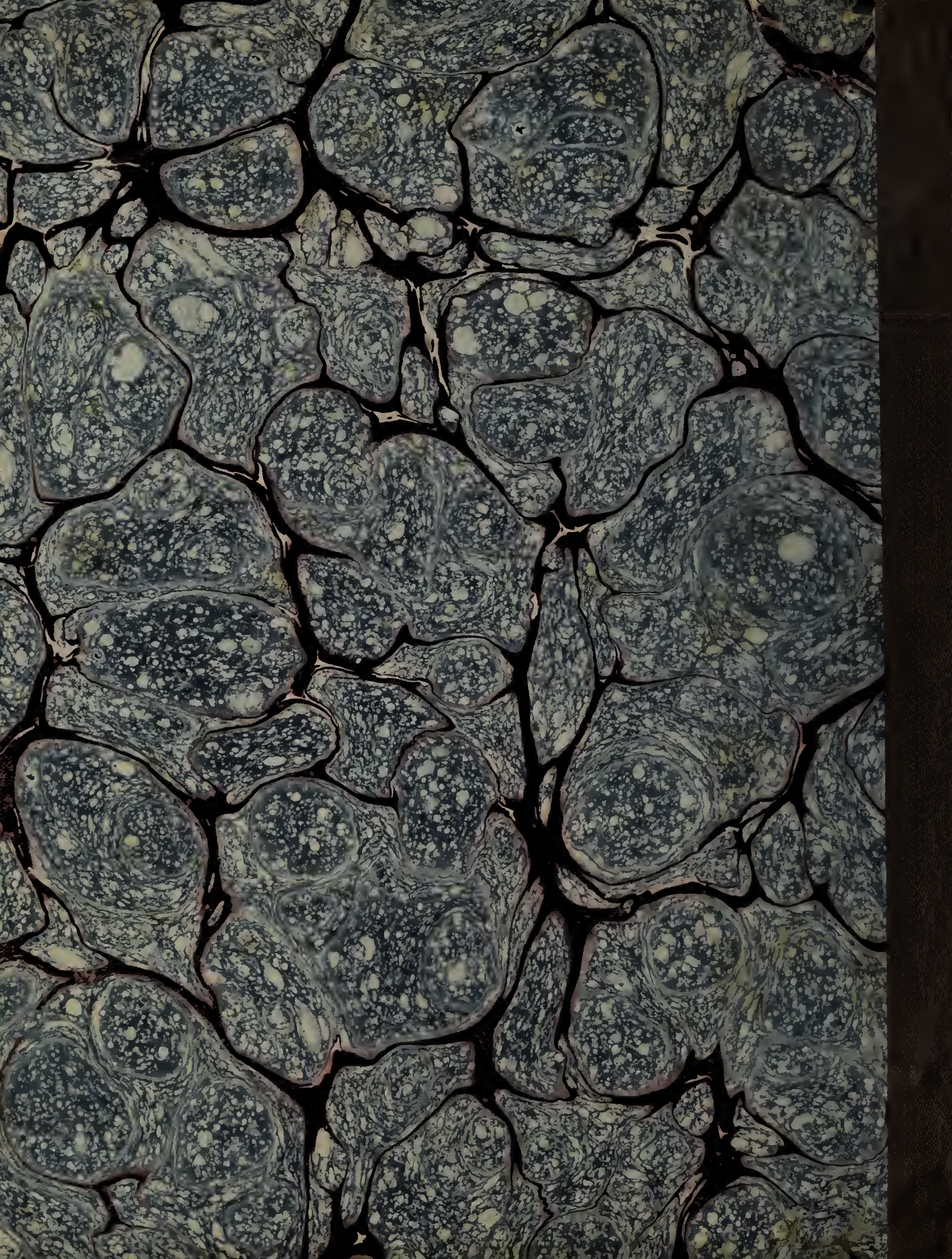

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T. S. Duché pinxit

Truth discovering to Time, Science
instructing her Children in the Improvements on the Microscope.

R Smith.

# ESSAYS
## ON THE
# MICROSCOPE;

CONTAINING
A PRACTICAL DESCRIPTION OF THE MOST IMPROVED
MICROSCOPES:
A GENERAL HISTORY of INSECTS,
THEIR
TRANSFORMATIONS, PECULIAR HABITS, AND ŒCONOMY:
AN ACCOUNT OF THE
*VARIOUS SPECIES AND SINGULAR PROPERTIES OF THE*
HYDRÆ AND VORTICELLÆ:
A DESCRIPTION OF
Three Hundred and Seventy-Nine Animalcula,
WITH A CONCISE
CATALOGUE OF INTERESTING OBJECTS:
A VIEW OF THE
ORGANIZATION OF TIMBER,
AND THE
CONFIGURATION OF SALTS WHEN UNDER THE MICROSCOPE.

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By GEORGE ADAMS,
MATHEMATICAL INSTRUMENT MAKER TO HIS MAJESTY, AND OPTICIAN
TO HIS ROYAL HIGHNESS THE PRINCE OF WALES.

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## TO THE

# KING.

SIR,

EVERY work that tends to enlarge the boundaries of ſcience, has a peculiar claim to the protection of Kings. He that diffuſes ſcience, civilizes man, opens the inlets to his happineſs, and co-operates with the Fountain and Source of all knowledge. By ſcience truth is advanced; and of DIVINE TRUTH Kings are the repreſentatives.

The work which I have now the honour to preſent to YOUR MAJESTY, calls the attention of the reader to thoſe laws of Divine order by which the univerſe is governed and ſupported: in it we find that the minuteſt beings ſhare in the protection, and triumph in the bounty of the Sovereign of all things: that the infinitely ſmall manifeſt to the aſtoniſhed eye the ſame proportion, regularity, and deſign, which are conſpicuous to the unaſſiſted ſight in the larger parts of creation. By finding all things formed in beauty, and produced for uſe, the mind is raiſed from the fleeting and evaneſcent appearances of matter to contemplate the permanent principles of truth, and acknowledge that the whole proceeds from the wiſdom that originates in love.

It was by YOUR MAJESTY's goodneſs and gracious patronage that I was firſt induced to undertake a deſcription of mathematical and philoſophical inſtruments, that I might thereby facilitate the attainment of thoſe ſciences that are connected with them, and by ſhewing what was already obtained, excite emulation, and quicken invention.

It is to the ſame goodneſs that I am indebted for this opportunity of ſubſcribing myſelf,

SIR,

YOUR MAJESTY's

Moſt humble,

Moſt obedient,

and moſt dutiful

Subject and Servant,

GEORGE ADAMS.

# PREFACE.

IN the preface to my ESSAYS ON ELECTRICITY AND MAGNETISM, I informed the public that it was my intention to publiſh, from time to time, eſſays deſcribing the conſtruction and explaining the uſe of mathematical and philoſophical inſtruments, in their preſent ſtate of improvement. This work will, I hope, be conſidered as a performance of my promiſe, ſo far as relates to the ſubject here treated of.

The firſt chapter contains a ſhort hiſtory of the invention and improvements that have been made on the microſcope, and Father Torrè's method of making his celebrated glaſs globules. The ſecond treats of viſion, in which I have endeavoured to explain, in a familiar manner, the reaſon of thoſe advantages which are obtained by the uſe of magnifying lenſes; but as the reader is ſuppoſed to be unacquainted with the elements of this ſcience, ſo many intermediate ideas have been neceſſarily omitted, as muſt in ſome degree leſſen the force, and weaken the perception of the truths intended to be inculcated: to have given theſe would have required a treatiſe on optics.

In the third chapter, the moſt improved microſcopes, and ſome others which are in general uſe, are particularly deſcribed; no pains have been ſpared to leſſen the difficulty of obſervation, and remove obſcurity from deſcription; the relative advantages of each inſtrument are briefly pointed out, to enable the reader to ſelect that which is beſt adapted to his purſuits. The method of preparing different objects for obſervation, and the cautions neceſſary to be obſerved in the uſe of the microſcope, are the ſubject of the fourth chapter.

When I firſt undertook the preſent eſſays, I had confined myſelf to a re-publication of my father's work, entitled, Micrographia Illuſtrata; but I ſoon found that both his and Mr. Baker's tracts on the microſcope were very imperfect. Natural hiſtory had not been ſo much cultivated at the period when they wrote, as it is in the preſent day. To the want of that information which is now eaſily obtained, we may, with propriety, impute their errors and imperfections. I have endeavoured to remedy their defects, by arranging the ſubjects in ſyſtematic order, and by introducing the microſcopic reader to the ſyſtem of Linnæus, as far as relates to inſects: by this he will learn to diſcriminate one inſect from another, to characterize their different parts, and thus be better enabled to convey inſtruction to others, and to avoid error himſelf.

As the transformations which inſects undergo, conſtitute a principal branch of their hiſtory, and furniſh many objects for the microſcope, I have given a very ample deſcription of them; the more ſo, as many microſcopic writers, by not conſidering theſe changes with attention, have fallen into a variety of miſtakes.

Here I intended to ſtop; but the charms of natural hiſtory are ſo ſeducing, that I was led on to deſcribe the peculiar and ſtriking marks in the œconomy of theſe little creatures. And ſhould the purchaſer of theſe eſſays receive as much pleaſure in reading this part as I did in compiling it; ſhould it induce him to ſtudy this branch of nature; nay, ſhould it only lead him to read the ſtupendous work of the moſt excellent Swammerdam, he will have no reaſon to regret his purchaſe, and one of my warmeſt wiſhes in compiling it will be gratified.

In the next chapter I have endeavoured to give the reader ſome idea of Mr. Lyonet's "anatomical and microſcopical deſcription of the coſſus, or caterpillar of the willow." As this book is but little known in our country, I thought that a ſpecimen of the indefatigable labour of this patient and humane anatomiſt would be acceptable to all lovers of the microſcope; and I have, therefore, appropriated a plate, which, while it ſhews what may be effected when microſcopic obſervation is accompanied by patience and induſtry, diſplays alſo the wonderful organization of this inſect. This is followed by a deſcription of many miſcellaneous objects; objects, of which no idea could be formed without the aſſiſtance of glaſſes.

To deſcribe the freſh-water polype, or hydra; to give a ſhort hiſtory of the diſcovery of theſe curious animals, and ſome account of their ſingular properties, is the buſineſs of the ſucceeding chapter. The properties of theſe animals are ſo extraordinary, that they were conſidered at firſt to be as contrary to the common courſe of nature, as they really were to the received opinions of animal life. Indeed, who can even now contemplate, without aſtoniſhment, animals that multiply by ſlips and ſhoots like a plant, that may be grafted together as one tree to another, that may be turned inſide out like a glove, and yet live, act, and perform all the various functions of their little ſpheres. As nearly allied to theſe, the chapter finiſhes with an account of thoſe vorticellæ which have been enumerated by Linnæus. It has been my endeavour to diſſipate confuſion, by the introduction of order, to diſpoſe into method, and ſelect under proper heads the ſubſtance of all that is known relative to theſe little creatures, and in the compaſs of a few pages to give the reader the information that is diſperſed through volumes.

From the hydræ and vorticellæ it was natural to proceed to the animalcula which are to be found in vegetable infuſions. Microſcopic beings, that ſeem as it were to border on the infinitely ſmall, that leave no ſpace deſtitute of inhabitants, and are of greater importance in the immenſe ſcale of beings than our contracted imagination can conceive, yet ſmall as they are, each of them poſſeſſes all that beauty and proportion of organized texture which is neceſſary to it's well being, and ſuited to the happineſs it is called forth to enjoy. I have pointed out the decided characters which fix them in the ſcale of animal life, characters that it is preſumed are a full confutation of the fanciful theories of Needham and Buffon. A ſhort account of three hundred and ſeventy-nine of theſe minute beings is then given, agreeable to the ſyſtem of the laborious Muller,* enlarging conſiderably his deſcription of thoſe animalcula that are moſt eaſily met with, better known, and conſequently more intereſting to the generality of readers.

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* Muller, Animalcula Infuſoria.

The conſtruction of timber, and the diſpoſition of it's component parts, as ſeen by the microſcope, is the ſubject of the next chapter; a ſubject confeſſedly obſcure. With what degree of ſucceſs this attempt has been proſecuted, muſt be left to the judgment of the reader. The beſt treatiſe on this part of vegetation is that of Mr. Duhamel du Monceaus "ſur la Phyſique des Arbres." If either my time, or ſituation in life, would have permitted it, I ſhould have followed his plan; but being confined to buſineſs, and to London, I can only recommend it to thoſe lovers of the works of the Almighty, who live in the country, to purſue this important branch of natural hiſtory. There is no doubt but that new views of the operations in nature, and of the wiſdom with which all things are contrived, would amply repay the labour of inveſtigation. Every part of the vegetable kingdom is rich in microſcopic beauties, from the ſtatelieſt tree of the foreſt, from the cedar of Lebanon, to the lowlieſt moſs, and the hyſſop that ſpringeth out of the wall, all conſpiring to ſay how much is hid from the natural ſight of man, how little can be known till it receives aſſiſtance, and is benefited by adventitious aid.

From the wonderful organization of animals, and the curious texture of vegetables, we proceed to the mineral kingdom, and take a curſory view of the configuration of ſalts and ſaline ſubſtances, exhibiting a few ſpecimens of the beautiful order in which they arrange themſelves under the eye, after having been ſeparated by diſſolution: every ſpecies working as it were upon a different plan, and producing cubes, pyramids, hexagons, or ſome other figure peculiar to itſelf, with a conſtant regularity amidſt boundleſs variety.

Though all nature teems with objects for the microſcopic obſerver, yet ſuch is the indolence of the human mind, or ſuch it's inattention to what is obvious, that among the purchaſers of microſcopes many have complained that they knew not what ſubjects to apply to their inſtrument, or where to find objects for examination. To obviate this complaint, a catalogue is here given, which is interſperſed with the deſcription of a few inſects, and other objects, which could not be conveniently introduced in the foregoing chapters. By this catalogue it is hoped that the uſe of the microſcope will be extended, and the path of obſervation facilitated.

To avoid the faſtidious parade of quotation, and the charge of plagiariſm, I have ſubjoined to this preface a liſt of the authors I have conſulted. As my extracts were made at very diſtant periods, it would have been impoſſible for me to remember to whom I was indebted for every new fact, or ingenious obſervation. It may, however, be neceſſary to inform the reader, that Mr. Marſham gave me the Linnæan names for the inſects which are deſcribed in this work.

The plates were drawn and engraved with a view to be folded up with the work; but as it is the opinion of many of my friends that they would, by this means, be materially injured, I have been adviſed to have them ſtitched in ſtrong blue paper, and leave it to the purchaſer to diſpoſe of them to his own mind.

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* * *

# ESSAYS

# ON THE

# MICROSCOPE.

## CHAP. I.

### A Concise History of the Invention and Improvements which have been made upon the Instrument called a Microscope.

IT is generally ſuppoſed, that microſcopes were invented about the year 1680, a period fruitful in diſcoveries, a time when the mind began to emancipate itſelf from thoſe errors and prejudices by which it had been too long enſlaved, to aſſert it's rights, extend it's powers, and follow the paths which lead to truth. The honor of the invention is claimed by the Italians and the Dutch; the name of the inventor, however, is loſt; probably the diſcovery did not at firſt appear ſufficiently important, to engage the attention of thoſe men, who, by their reputation in ſcience, were able to eſtabliſh an opinion of it's merit with the reſt of the world, and hand down the name of the inventor to ſucceeding ages. Men of great literary abilities are too apt to deſpiſe the firſt dawnings of invention, not conſidering that all real knowledge is progreſſive, and that what they deem trifling may be the firſt and neceſſary link to a new branch of ſcience.

The microſcope extends the boundaries of the organs of viſion, enables us to examine the ſtructure of plants and animals; preſents to the eye myriads of beings, of whoſe exiſtence we had before formed no idea; opens to the curious an exhauſtleſs ſource of information and pleaſure; and furniſhes the philoſopher with an unlimited field of inveſtigation. It leads, to uſe the words of an ingenious writer, to the diſcovery of a thouſand wonders in the works of his hand, who created ourſelves, as well as the objects of our admiration; it improves the faculties, exalts the comprehenſion, and multiplies the inlets to happineſs; is a new ſource of praiſe to him, to whom all we pay is nothing of what we owe; and while it pleaſes the imagination with the unbounded treaſures it offers to the view, it tends to make the whole life one continued act of admiration.

It is not difficult to fix the period when the microſcope firſt began to be generally known, and was uſed for the purpoſe of examining minute objects; for though we are ignorant of the name of the firſt inventor, we are acquainted with the names of thoſe who introduced it into public view, and engaged their attention to it, by exhibiting ſome of it's wonderful effects. Zacharias Janſens and his ſon had made microſcopes before the year 1619, for in that year the ingenious Cornelius Drebell brought one, which was made by them, with him into England, and ſhewed it to William Borrell and others. It is poſſible this inſtrument of Drebell's was not ſtrictly what is now meant by a microſcope, but was rather a kind of microſcopic teleſcope, ſomething ſimilar in principle to that lately deſcribed by Mr. Aepinus, in a letter to the Academy of Sciences at Peterſburg. It was formed of a copper tube ſix feet long and one inch diameter, ſupported by three braſs pillars in the ſhape of dolphins; theſe were fixed to a baſe of ebony, on which the objects to be viewed by the microſcope were alſo placed. In contradiction to this, Fontana, in a work which he publiſhed in 1646, ſays, that he had made microſcopes in the year 1618: this may be alſo very true, without derogating from the merit of the Janſens, for we have many inſtances in our own times of more than one perſon having executed the ſame contrivance, nearly at the ſame time, without any communication from one to the other. In 1685, Stelluti publiſhed a deſcription of the parts of a bee, which he had examined with a microſcope.

If we conſider the microſcope as an inſtrument conſiſting of one lens only, it is not at all improbable, that it was known to the ancients much ſooner than the laſt century, nay, even in a degree to the Greeks and Romans: for it is certain, that ſpectacles were in uſe long before the above-mentioned period: now as the glaſſes of theſe were made of different convexities, and conſequently of different magnifying powers, it is natural to ſuppoſe, that ſmaller and more convex lenſes were made, and applied to the examination of minute objects. In this ſenſe, there is alſo ſome ground for thinking the ancients were not ignorant of the uſe of lenſes, or at leaſt of what approached nearly to, and might in ſome inſtances be ſubſtituted for them. The two principal reaſons which ſupport this opinion are, firſt, the minuteneſs of ſome ancient pieces of workmanſhip, which are to be met with in the cabinets of the curious: the parts of ſome of theſe are ſo ſmall, that it does not appear at preſent how they could have been executed without the uſe of magnifying glaſſes, or of what uſe they could have been when executed, unleſs they were in poſſeſſion of glaſſes to examine them with. A remarkable piece of this kind, a ſeal with very minute work, and which to the naked eye appears very confuſed and indiſtinct, but beautiful when examined with a proper lens, is deſcribed "Dans l'Hiſtoire de l'Academie des Inſcriptions," tom. 1. p. 333. The ſecond argument is founded on a great variety of paſſages, that are to be ſeen in the works of Jamblichus, Pliny, Plutarch, Seneca, Agellius, Piſidias, &c. From theſe paſſages it is evident that they were enabled by ſome inſtrument, or other means, not only to view diſtant objects, but alſo to magnify ſmall ones; for if this is not admitted, the paſſages appear abſurd, and not capable of having a rational meaning applied to them. I ſhall only adduce a ſhort paſſage from Piſidias, a chriſtian writer of the ſeventh century, Τα μελλοντα ως δια διοπτρȣ συ βλεπεις· "You ſee things future by a *dioptrum*:" now we know of nothing but a proſpective glaſs or ſmall teleſcope, whereby things at a diſtance may be ſeen as if they were near at hand, the circumſtance on which the ſimile was founded. It is alſo clear, that they were acquainted with, and did make uſe of that kind of microſcope, which is even at this day commonly ſold in our ſtreets by the Italian pedlars, namely, a glaſs bubble filled with water. Seneca plainly affirms it, *Literæ quamvis minutæ et obſcuræ, per vitream pilam aquâ plenam, majores clarioreſque cernuntur.*" Nat. Quæſt. lib. 1. cap. 7. "Letters, though minute and obſcure, appear larger and clearer through a glaſs bubble filled with water." Thoſe who wiſh to ſee further evidence concerning the knowledge of the ancients in optics, may conſult Smith's Optics, Dr. Prieſtley's Hiſtory of Light and Colours, the Appendix to an Eſſay on the firſt Principles of Natural Philoſophy by the Rev. Mr. Jones, Dr. Rogers's Diſſertation on the Knowledge of the Ancients, and Mr. Duten's Enquiry into the Origin of the Diſcoveries attributed to the moderns.

The hiſtory of the microſcope, like that of nations and arts, has had it's brilliant periods, in which it has ſhone with uncommon ſplendor, and been cultivated with extraordinary ardour; theſe have been ſucceeded by intervals marked with no diſcovery, and in which the ſcience ſeemed to fade away, or at leaſt lie dormant, till ſome favorable circumſtance, the diſcovery of a new object, or ſome new improvement in the inſtruments of obſervation, awakened the attention of the curious, and animated their reſearches. Thus, ſoon after the invention of the microſcope, the field it preſented to obſervation was cultivated by men of the firſt rank in ſcience, who enriched almoſt every branch of natural hiſtory, by the diſcoveries they made with this inſtrument: there is indeed ſcarce any object ſo inconſiderable, that it has not ſomething to invite the curious eye to examine it; nor is there any, which, when properly examined, will not amply repay the trouble of inveſtigation.

I ſhall firſt ſpeak of the SINGLE MICROSCOPE, not only as it is the moſt ſimple, but becauſe, as we have already obſerved, it was invented and uſed long before the double or compound microſcope. When the lenſes of the ſingle microſcope are very convex, and conſequently the magnifying power very great, the field of view is ſo ſmall, and it is ſo difficult to adjuſt with accuracy their focal diſtance, that it requires ſome practice to render the uſe thereof familiar; at the ſame time, the ſmallneſs of the aperture to theſe lenſes has been found injurious to the eyes of ſome obſervers: notwithſtanding, however, theſe defects, the great magnifying power, as well as the diſtinct viſion which is obtained by the uſe of a deep ſingle lens, more than counterballances every difficulty and diſadvantage. It was with this inſtrument that Leeuwenhoek and Swammerdam, Lyonet and Ellis examined the minima of nature, laid open ſome of her hidden receſſes, and by their example ſtimulated others to the ſame purſuit.

The conſtruction of the ſingle microſcope is ſo ſimple, that it is ſuſceptible of but little improvement, and has therefore undergone but few alterations; and theſe have been chiefly confined to the mode of mounting it, or the additions to it's apparatus. The greateſt improvement this inſtrument has received, was made by Dr. Lieberkuhn, about the year 1740; it conſiſted in placing the ſmall lens in the center of a highly-poliſhed concave ſpeculum of ſilver, by which means he was enabled to reflect a ſtrong light upon the upper ſurface of an object, and thus examine it with great eaſe and pleaſure. Before this contrivance, it was almoſt impoſſible to examine ſmall opake objects with any degree of exactneſs and ſatisfaction; for the dark ſide of the object being next the eye, and alſo overſhadowed by the proximity of the inſtrument, it's appearance was neceſſarily obſcure and indiſtinct.

Dr. Lieberkuhn adapted a microſcope to every object; they conſiſted of a ſhort braſs tube, at the eye end of which a concave ſilver ſpeculum was fixed, and in the center of the ſpeculum a magnifying lens: the object was placed in the middle of the tube, and had a ſmall adjuſtment to regulate it to the focus; at the other end of the tube there was a plano convex lens, to condenſe and render more uniform the light which was reflected from the mirror. But all this pains was not beſtowed upon trifling objects; his were generally the moſt curious anatomical preparations, a few of which, with their microſcopes, are (I believe) depoſited in the Britiſh Muſeum. It will be proper, in this place, to give ſome account of M. Leeuwenhoek's microſcopes, which were rendered famous throughout all Europe, on account of the numerous diſcoveries he had made with them, as well as from his afterwards bequeathing a part of them to the Royal Society. The microſcopes he uſed were all ſingle, and fitted up in a convenient ſimple manner; each of them conſiſted of a very ſmall double convex lens, let into a ſocket between two plates rivetted together, and pierced with a ſmall hole; the object was placed on a ſilver point or needle, which, by means of ſcrews adapted for that purpoſe, might be turned about, raiſed or depreſſed at pleaſure, and thus be brought nearer to, or be removed farther from the glaſs, as the eye of the obſerver, the nature of the object, and the convenient examination of it's parts required. M. Leeuwenhoek fixed his objects, if they were ſolid, to the foregoing point with glue; if they were fluid, he fitted them on a little plate of talc, or exceeding thin blown glaſs, which he afterwards glued to the needle, in the ſame manner as his other objects. The glaſſes were all exceeding clear, and of different magnifying powers, which were proportioned to the nature of the object, and the parts deſigned to be examined. But none of thoſe, which were preſented to the Royal Society, magnified ſo much, as the glaſs globules, which have been uſed in other microſcopes. He had obſerved, in a letter of his to the Royal Society, that from upwards of forty years experience, he found that the moſt conſiderable diſcoveries were to be made with ſuch glaſſes, as, magnifying but moderately, exhibited the object with the moſt perfect brightneſs and diſtinctneſs. Each inſtrument was devoted to one or two objects: hence he had always ſome hundreds by him. * There is ſome reaſon for ſuppoſing, that Leeuwenhoek was acquainted with a mode of viewing opake objects, ſimilar to that invented by Dr. Lieberkuhn. †

About the year 1665, ſmall glaſs globules began to be occaſionally applied to the ſingle microſcope, inſtead of convex lenſes. By theſe globules, an immenſe magnifying power is obtained. The invention of them has been generally attributed to M. Hartſoeker; it appears, however, to me, that we are indebted to the celebrated Dr. Hooke for this diſcovery; for he deſcribed the manner of making them in the preface to his Micrographia Illuſtrata, which was publiſhed in the year 1656. Now the firſt account we have of any microſcopical diſcovery by M. Hartſoeker, was that of the ſpermatic animalculæ, made by him when he was eighteen years old; which brings us down to the year 1674, long after Dr. Hooke's publication.

As theſe glaſs globules have been very uſeful in the hands of experienced obſervers, I ſhall lay before my readers the different

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* Philoſophical Tranſactions, No. 380, No. 458.

† Prieſtley's Hiſtory of Optics, p. 220.

different modes which have been deſcribed for making them, that he may be enabled thereby to verify or confute the diſcoveries that have been ſaid to be made with them.

Take a ſmall rod * of the cleareſt and cleaneſt glaſs you can procure, free, if poſſible, from blebs, veins, or ſandy particles; then by melting it in a lamp made with ſpirit of wine, or the pureſt and cleareſt ſallad oil, draw it out into exceeding fine and ſmall threads; take a ſmall piece of theſe threads, and melt the end thereof in the ſame flame, till you perceive it run into a ſmall drop or globule of the deſired ſize; let this globule cool, then fix it, upon a thin plate of braſs or ſilver, ſo that the middle of it may be directly over the center of a very ſmall hole made in this plate, handling it till it is fixed, by the before-mentioned thread of glaſs. When the plate is properly ſixed to your microſcope, and the object adjuſted to the focal diſtance of the globule, you will perceive the object diſtinctly and immenſly magnified. By this means, ſays Dr. Hooke, I have been able to diſtinguiſh the particles of bodies, not only a million of times ſmaller than a viſible point, but even to make thoſe viſible whereof a million of millions would hardly make up the bulk of the ſmalleſt viſible grain of ſand; ſo prodigiouſly do theſe exceeding ſmall globules enlarge our proſpect into the more hidden receſſes of nature.

Mr. Butterfield, in making of the globules, uſed a lamp with ſpirit of wine; but inſtead of a cotton wick, he uſed fine ſilver wire, doubled up and down like a ſkain of thread. † He prepared

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* Lectures and Collections by Dr. Hooke.

† Philoſ. Tranſ. No. 141.

pared his glaſs by beating it to powder, and waſhing it very clean; he then took a little of this glaſs upon the ſharp point of a ſilver needle, wetted with ſpittle, and held it in the flame, turning it about till a glaſs ball was formed; then taking it from the flame, he afterwards cleaned it with ſoft leather, and ſet it in a braſs cell.

No perſon has carried the uſe of theſe globules ſo far as T. Di Torrè, of Naples, nor been ſo dexterous in the execution of them; and if others have not been able to follow him in the ſame line, it may be fairly attributed to a want of that delicacy of touch for adjúſting the objects to their focus, and that acuteneſs of viſion which can only be acquired by long practice. P. Torrè has alſo deſcribed, more minutely than any other author, the mode of executing theſe globules, which, as it throws much light upon the preceding deſcription by Dr. Hooke, will not, it is preſumed, be unacceptable to the reader.

Three things are neceſſary for forming of theſe globules: 1. A lamp and bellows, ſuch as are uſed by the glaſs-blowers; 2. A piece of perfect tripoli; 3. A variety of ſmall glaſs rods. When the flame of the lamp is blown in an horizontal direction, it will be found to conſiſt of two parts; from the baſe to about two-thirds of it's length, it is of a white colour; beyond this, it is tranſparent, and colourleſs. It is this tranſparent part which is to be uſed for melting the glaſs, becauſe by this it will not be in the leaſt ſullied; but it will be immediately ſoiled, if it touches the white part of the flame. The part of the glaſs which is preſented to the flame, ought to be exceeding clean, and great care ſhould be taken that it be not touched by the fingers. If the glaſs rod has contracted any ſpots, it muſt either be thrown away, or the parts that are ſpotted muſt be cut off.

The piece of tripoli which is to be uſed in forming the globules, ſhould be flat on one ſide, and ſo large, that it may be handled conveniently, and protect the fingers from the flame. A piece four or five inches long, and three or four inches thick, will anſwer very well. The beſt tripoli for this purpoſe, is of a white colour, with a fine grain, heavy and compact, and which, after it has been calcined, is of a red colour. This kind reſiſts the fire beſt, is not apt to break when calcined, and the melted glaſs does not adhere to it. To calcine this tripoli, cover it well all round with charcoal nearly red hot, leaving it thus till the charcoal is quite cold; it may then be taken out. Let ſeveral hemiſpherical cavities be made on the flat ſide of the tripoli; they ſhould be of different ſizes, nicely poliſhed, and neatly rounded at the edges, in order to facilitate the entrance of the flame. The large globules are to be placed in the large cavities, and the minuter ones in the ſmall cavities. The holes in the tripoli muſt never be touched with the finger. If it is neceſſary to clean them, it ſhould be done with white paper; the larger globules may be cleaned with waſh leather. The glaſs rods ſhould be of various ſizes, as of 1-10th, 1-20th, 1-30th of an inch in diameter, as clean and free from ſpecks and bubbles as poſſible.

## TO MAKE SMALL GLASS MICROSCOPIC GLOBULES.

Take two rods of glaſs, one in each hand, place their extremities cloſe to each other, and in the pureſt part of the flame; when you perceive the ends to be fuſed, ſeparate them from each

other;

other; the heated glaſs following each rod, will be finer, in proportion to the length it is drawn to and the ſmallneſs of the rod; in this manner you may procure threads of glaſs of any degree of fineneſs. Direct the flame to the middle of the thread, and it will be inſtantly divided into two parts. When one of the threads is perfectly cool, place it at the extremity of the flame, by which it will be rendered round; and if the thread of glaſs be very fine, an exceeding ſmall globule will be formed. This thread may now be broke off from the rod, and a new one may be again drawn out as before, by the aſſiſtance of the other glaſs rod.

The ſmall ball is now to be ſeparated from the thread of glaſs; this is eaſily effected by the ſharp edge of a piece of flint. The ball ſhould be placed in a groove of paper, and another piece of paper be held over it, to prevent the ball from flying about and being loſt. A quantity of globules ought to be prepared in this manner; they are then to be cleaned, and afterwards placed in the cavities of the tripoli, by means of a delicate pair of nippers. The globules are now to be melted a ſecond time, in order to render them completely ſpherical; for this purpoſe, bring one of the cavities near the extremity of the flame, directing this towards the tripoli, which muſt be firſt heated; the cavity is then to be lowered, ſo that the flame may touch the glaſs, which, when it is red hot, will aſſume a perfect globular form; it muſt then be removed from the flame, and laid by; when cold, it ſhould be cleaned, by rubbing between two pieces of white paper. Let it now be ſet in a braſs cap, to try whether the figure be perfect. If the object is not well defined, the globule muſt be thrown away. Though, if it be large, it may be expoſed two or three times to the flame. When a large globule is forming, it ſhould be gently agitated by ſhaking the tripoli, which will prevent it's becoming flat on one ſide. By attending to theſe directions, the greater part of the globules will be round and fit for uſe. In damp weather, notwithſtanding every precaution, it will often happen, that out of forty globules, four or five only will be fit for uſe.

Mr. Stephen Gray, of the Charter-Houſe, having obſerved ſome irregular particles within a glaſs globule, and finding that they appeared diſtinct and prodigiouſly magnified when held cloſe to his eye, concluded that if he placed a globule of water, in which there were any particles more opake than the water, near his eye, he ſhould ſee thoſe particles diſtinctly and highly magnified. This idea, when realized, far exceeded his expectation. His method was, to take on a pin a ſmall portion of water which he knew had in it ſome minute animalculæ; this he laid on the end of a ſmall piece of braſs wire, till there was formed ſomewhat more than an hemiſphere of water; on applying it then to the eye, he found the animalculæ moſt enormouſly magnified; for thoſe which were ſcarce diſcernible with his glaſs globules, with this appeared as large as ordinary ſized peas. They cannot be ſeen by day-light, except the room be darkened, but are ſeen to the greateſt advantage by candle-light. Montucla obſerves, that when any objects are incloſed within this tranſparent globule, the hinder part of it acts like a concave mirror, provided they be ſituated between that ſurface and the focus; and that by this means they are magnified three times and a half more than they would be in the uſual way. An extempore microſcope may be formed, by taking up a ſmall drop of water on the point of a pin, and placing it over a fine hole made in a piece of metal; but as the refractive power of water is leſs than that of glaſs, theſe globules do not magnify ſo much as thoſe of the ſame ſize, which are made of glaſs: this was alſo contrived by Mr. Gray. The ſame ingenious author invented another water microſcope, conſiſting of two drops of water, ſeparated in part by a thin braſs plate, but touching near the center; which were thus rendered equivalent to a double convex lens, of unequal convexities.

Dr. Hooke deſcribes a method of uſing the ſingle microſcope, which ſeems to have a great analogy to the foregoing methods of Mr. Gray. If you are deſirous (he ſays) of obtaining a microſcope with one ſingle refraction, and conſequently capable of procuring the greateſt clearneſs and brightneſs any one kind of microſcope is ſuſceptible of; ſpread a little of the fluid you intend to examine on a glaſs plate, bring this under one of your microſcopic globules, then move it gently upwards, till the fluid touches the globule, to which it will ſoon adhere, and that ſo firmly, as to bear being moved a little backwards or forwards. By looking through the globule, you will then have a perfect view of the animalculæ in the drop. *

Having laid before the reader the principal improvements that have been ſuggeſted or made in the ſingle microſcope, it remains only to point out thoſe inſtruments of this kind, which, from the mode in which they are fitted up, ſeem beſt adapted for general uſe; the peculiar advantages of which, as well as the manner of uſing them, will be deſcribed in the third chapter of this work.

Fig.

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* Hooke's Lectures and Conjectures, p. 98.

Fig. 3. Plate VI. repreſents that which was uſed by M. Lyonnet for diſſecting the coſſus.

Fig. 1. Plate VII. B. The aquatic microſcope uſed by Mr. Ellis for inveſtigating the nature of coralline, and recommended by Mr. Curtis to botaniſts, in his Flora Londinenſis.

Fig. 1. Plate VI. A botanical microſcope, contrived by Dr. Withering.

Fig. 2. Plate VI. A botanical microſcope, by Mr. B. Martin.

Fig. 5. Plate VI. The tooth and pinion microſcope, which is now generally ſubſtituted in the room of Wilſon's.

Fig. 8. Plate VIII. A botanical magnifier.

Fig. 7. Plate VIII. A different kind of botanical magnifier.

A COMPOUND MICROSCOPE, as it conſiſts of two, three, or more glaſſes, is more eaſily varied, and is ſuſceptible of greater changes in it's conſtruction, than the ſingle microſcope. The number of the lenſes, of which it is formed, may be increaſed or diminiſhed, their reſpective poſitions may be varied, and the form in which they are mounted be altered almoſt ad infinitum. But among theſe varieties, ſome will be found more deſerving of attention than others; it is of theſe only we ſhall ſpeak in this place.

The three firſt compound microſcopes that attract our notice, are thoſe of Dr. Hooke, Euſtachio Divini, and Philip Bonnani. Dr. Hooke gives an account of his in the preface to his Micrographia, which was publiſhed in the year 1656; it was about three inches in diameter, ſeven long, and furniſhed with four draw-out tubes, by which it might be lengthened as occaſion required: it had three glaſſes, a ſmall object glaſs, a middle glaſs, and a deep eye glaſs: Dr. Hooke uſed all the glaſſes when he wanted to take in a conſiderable part of an object at once, as by the middle glaſs a number of radiating pencils were conveyed to the eye, which would otherwiſe have been loſt: but when he wanted to examine with accuracy the ſmall parts of any ſubſtance, he took out the middle glaſs, and only made uſe of the eye and object lenſes; for the fewer the refractions are, the clearer and more bright the object appears.

An account of Euſtachio Divini's microſcope was read at the Royal Society, in 1668.* It conſiſted of an object lens, a middle glaſs, and two eye glaſſes, which were plano convex lenſes, and were placed ſo that they touched each other in the center of their convex ſurfaces; by which means the glaſs takes in more of an object, the field is larger, the extremities of it leſs curved, and the magnifying power greater. The tube, in which the glaſſes were incloſed, was as large as a man's leg, and the eye glaſſes as broad as the palm of the hand. It had four ſeveral lengths; when ſhut up, it was ſixteen inches long, and magnified the diameter of an object forty-one times; at the ſecond length, ninety times; at the third length, one hundred and eleven times;

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* Philoſ. Tranſ. No. 42.

at the fourth length, one hundred and forty-three times. It does not appear that E. Divini varied the object lenſes.

Philip Bonnani publiſhed an account of his two microſcopes in 1698;* both were compound; the firſt was ſimilar to that which Mr. Martin publiſhed as new, in his Micrographia Nova,† in 1712. His ſecond was like the former, compoſed of three glaſſes, one for the eye, a middle glaſs, and an object lens: they were mounted in a cylindrical tube, which was placed in an horizontal poſition; behind the ſtage was a ſmall tube, with a convex lens at each end; beyond this was a lamp; the whole capable of various adjuſtments, and regulated by a pinion and rack; the ſmall tube was uſed to condenſe the light on the object, and ſpread it uniformly over it according to it's nature, and the magnifying power that was uſed.

If the reader attentively conſiders the conſtruction of the foregoing microſcopes, and compares them with more modern ones, he will be led to think with me, that the compound microſcope has received very little improvement ſince the time of Bonnani. Taken ſeparately, the foregoing conſtructions are equal to ſome of the moſt famed modern microſcopes. If their advantages are combined, they are far ſuperior to that of M. Dellebarre, notwithſtanding the pompous eulogium affixed thereto by Meſſ. De L'Academie Royale des Sciences. ‡

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* Bonnani Obſervationes circa viventia, &c.

† Micrographia Nova, by B. Martin, 4to.

‡ Memoires ſur les Differences de la Conſtruction et des Effets du Microſcope, de M. L. F. Dellebarre, 1777.

From this period, to the year 1736, the microſcope appears not to have received any conſiderable alteration, but the ſcience itſelf to have been at a ſtand. The improvements which were making in the reflecting teleſcope, naturally led thoſe who had turned their thoughts this way, to expect a ſimilar ſervice for microſcopes on the ſame principles: accordingly we find two plans of this kind; the firſt was that of Dr. Robert Barker. This inſtrument is entirely the ſame as the reflecting teleſcope, excepting the diſtance of the two ſpeculums, which is lengthened, in order to adapt it to thoſe pencils of rays which enter the teleſcope diverging; whereas, from very diſtant objects, they come in a direction nearly parallel. But this was ſoon laid aſide, not only as it was more difficult to manage, but alſo becauſe it was unfit for any but very ſmall or tranſparent objects: for the object being between the ſpeculum and the image, would, if it were large and opake, prevent a due reflection of light on the object.

The ſecond was contrived by Dr. Smith.* In this there were two reflecting mirrors, one concave, and the other convex; the image was viewed by a lens. This microſcope, though far from being executed in the beſt manner, performed, ſays Dr. Smith, very well, ſo that he did not doubt but what it would have excelled others, if it had been properly finiſhed.

As ſome years are more favorable to the fruits of the earth, ſo alſo ſome periods are more favorable to particular ſciences, being rich in diſcovery, and cultivated with ardor. Thus, in the year

1738,

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* Dr. Smith's Optics, Remarks, p. 94.

1738, Mr. Lieburkuhn's invention of the ſolar microſcope was communicated to the public: the vaſt magnifying power which was obtained by this inſtrument, the coloſſal grandeur with which it exhibited the minima of nature, the pleaſure which aroſe from being able to diſplay the ſame object to a number of obſervers at the ſame time, by affording a new ſource of rational amuſement, increaſed the number of microſcopic obſervers, who were further ſtimulated to the ſame purſuits by Mr. Trembley's famous diſcovery of the polype: the wonderful properties of this little animal, together with the works of Mr. Trembley, Baker, and my father, revived the reputation of this inſtrument. *

Every optician now exerciſed his talents in improving (as he called it) the microſcope; in other words, in varying it's conſtruction, and rendering it different from that ſold by his neighbour. Their principal object ſeemed to be, only to ſubdivide the inſtrument, and make it lie in as ſmall a compaſs as poſſible; by which means, they not only rendered it complex, and troubleſome in uſe, but loſt ſight alſo of the extenſive field, great light, and other excellent properties of the more ancient inſtruments; and in ſome meaſure, ſhut themſelves out from further improvements on the microſcope. Every mechanical inſtrument is ſuſceptible of almoſt infinite combinations and changes, which are attended with their relative advantages and diſadvantages: thus, what is gained in power, is loſt in time; " he that loves to be confined to a ſmall houſe, muſt loſe the benefit of air and exerciſe."

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* Trembley Memoires ſur les Polypes. Baker's Microſcope made Eaſy; Attempt towards an Hiſtory of the Polype; Employment for the Microſcope. Adams's Micrographia Illuſtrata. Joblot's Obſervations d'Hiſtoire Naturelle.

The microſcope, nearly at the ſame period, gave riſe to M. Buffon's famous ſyſtem of organic molecules, and M. Needham's incomprehenſible ideas concerning a vegetative force and the vitality of matter. M. Buffon has dreſſed up his ſyſtem with all the charms of eloquence, preſenting it to the mind in the moſt agreeable and lively colours, exerting the depths of erudition in the moſt intereſting and ſeducing manner, to eſtabliſh his hypotheſis, making us almoſt ready to adopt it againſt the dictates of reaſon, and the evidence of facts. But whether this great man was miſled by the warmth of his imagination, his attachment to a favorite ſyſtem, or the uſe of imperfect inſtruments, it appears but too evident, that he was not acquainted with the objects whoſe nature he attempted to inveſtigate; and it is probable, that he never ſaw * thoſe which he ſuppoſed he was deſcribing, continually confounding the animalculæ produced from the putrifying decompoſition of animal ſubſtances, with the ſpermatic animalculæ, although they are two kinds of beings, differing in form and nature; ſo that the beautiful fabric attempted to be raiſed on his hypotheſis, vaniſhes before the light of truth and well conducted experiments.

After this period, the mind, either ſatisfied with the diſcoveries already made, (which will be particularly deſcribed hereafter) or tired by it's own exertions, ſought for repoſe in other purſuits; ſo that for ſeveral years this inſtrument was again, in ſome meaſure,

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* Porro Buffonius, ut cum illuſtris viri venia dicam omnino non videtur, vermiculos ſeminales vidiſſe. Diuturnitas enim vitæ quam ſuis corpuſculis tribuit, oſtendit non eſſe noſtra animalcula (id eſt, ſpermatica) quibus brevis et paucarum horarum vita eſt. Haller Phyſiol. tom. 7.

ſure, laid aſide. In 1770, Dr. Hill * publiſhed a treatiſe, in which he endeavours to explain the conſtruction of timber by the microſcope, and ſhew the number, the nature, and office of it's ſeveral parts, their various arrangements and proportions in the different kinds; and point out a way of judging, from the ſtructure of trees, the uſes they will beſt ſerve in the affairs of life. So important a ſubject ſoon revived the ardor for microſcopic purſuits, which ſeems to have been increaſing ever ſince. About the ſame time, my father contrived an inſtrument for cutting the tranſverſe ſections of wood, in order that the texture thereof might be rendered more viſible in the microſcope, and conſequently be better underſtood; this inſtrument was afterwards improved by Mr. Cumming. Another inſtrument for the ſame purpoſe, more certain in it's effects, and more eaſily managed, is repreſented in fig. 1, plate 9; it will be deſcribed in one of the following chapters. Dr. Hooke and Mr. Cuſtance now endeavoured to bring back the microſcope nearer to the old ſtandard, to increaſe the field by the multiplication of the eye glaſſes, and to augment the light on the object, by condenſing lenſes; and in this they happily ſucceeded: Mr. Cuſtance was unrivalled in his dexterity in preparing, and accuracy in cutting thin tranſverſe ſections of wood.

In 1771, my father publiſhed a fourth edition of his Micrographia, in which he deſcribed the principal inventions then in uſe; particularly a contrivance of his own, for applying the ſolar microſcope to the camera obſcura, and illuminating it at night by a lamp,

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* Dr. Hill on the Conſtruction of Timber.

a lamp, by which means a picture of microſcopic objects might be exhibited in winter evenings.

It appears * from the teſtimony of M. Æpinus, that M. Lieburkuhn had conſiderably improved the ſolar microſcope, by adapting it to view opake objects. This contrivance was by ſome means loſt. The knowledge, however, that ſuch an effect had been produced, led Æpinus to attend to the ſubject himſelf, in which he in ſome meaſure ſucceeded, and would, no doubt, have brought it to perfection, if he had increaſed the ſize of his illuminating mirror. Some further improvements were made on this inſtrument by M. Ziehr; but the moſt perfect inſtrument of the kind, is that of Mr. B. Martin, who publiſhed an account of it in the year 1774.† The common ſolar microſcope does not ſhew the ſurface of any object, whereas the opake ſolar microſcope not only magnifies the object, but exhibits on a ſcreen an expanded picture of it's ſurface, with all it's colours, in a moſt beautiful manner.

About the year 1774, I invented the improved lucernal microſcope; this inſtrument does not in the leaſt fatigue the eye; it ſhews all opake objects in a moſt beautiful manner; and tranſparent objects may be examined by it in various ways, ſo that no part of an object is left unexplored; and the outlines of all may be taken with eaſe, even by thoſe who are moſt unſkilled in drawing.

M. L.

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* Prieſtley's Hiſt. of Optics, p. 743.

† Martin's Deſcription and Uſe of an Opake Solar Microſcope.

M. L. F. Dellebarre publiſhed an account of his microſcope in the year 1777. It does not appear from this, that it was ſuperior in any reſpect to thoſe that were then made in England, but was inferior in others; for thoſe publiſhed by my father in 1771, poſſeſſed all the advantages of Dellebarre's in a higher degree, except that of changing the eye glaſſes.

In 1784, M. Æpinus publiſhed a deſcription of what he termed new-invented microſcopes, in a letter to the Academie des Sciences de St. Peterſburg;* they are nothing more than an application of the acromatic perſpective to microſcopic purpoſes. Now it has been long known to every one who is the leaſt verſed in optics, that any teleſcope is eaſily converted into a microſcope, by removing the object glaſs to a greater diſtance from the eye glaſſes; and that the diſtance of the image varies with the diſtance of the object from the focus, and is magnified more, as it's diſtance from the object is greater: the ſame teleſcope may, therefore, be ſucceſſively turned into a microſcope, with different magnifying powers. Mr. Martin had alſo ſhewn, in his deſcription and uſe of a polydynamic microſcope, how eaſily the ſmall acromatic perſpective may be applied to this purpoſe. Botaniſts might find ſome advantage in attending to this inſtrument; it would aſſiſt them in diſcovering ſmall plants at a diſtance, and thus often ſave them from the thorns of the hedge, and the dirt of a ditch.

Fig. 1, Plate III. repreſents the improved lucernal microſcope.

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* Deſcription des Nouveaux Microſcopes, inventes par M. Æpinus.

Fig. 1, Plate V. repreſents a ſolar opake microſcope.

Fig. 4, Plate VI. is a picture of the common ſolar microſcope.

Fig. 3, Plate IV. is what is uſually called Culpeper's, or the three pillared microſcope.

Fig. 1, Plate IV. the improved double and ſingle microſcope.

Fig. 2, Plate IV. the beſt double conſtructed microſcope.

Fig. 1, Plate VII. A. the common double conſtructed microſcope.

Fig. 3, Plate VIII. a microſcopic teleſcope, or convenient portable apparatus for a traveller.

We cannot conclude this chapter better than with the following obſervations on the microſcope. We are indebted to it for many diſcoveries in natural hiſtory; but let us not ſuppoſe, that the Creator intended to hide theſe objects from our obſervation. It is true, this inſtrument diſcovers to us as it were a new creation, new ſeries of animals, new foreſts of vegetables; but he who gave being to theſe, gave us an underſtanding capable of inventing means to aſſiſt our organs in the diſcovery of their hidden beauties. He gave us eyes adapted to enlarge our ideas, and capable of comprehending a univerſe at one view, and conſequently incapable of diſcerning thoſe minute beings, with which he has peopled every atom of the univerſe. But then he gave properties and qualities to matter of a particular kind, by which it would procure us this advantage, and at the ſame time elevated the underſtanding from one degree of knowledge to another, till it was able to diſcover theſe aſſiſtances for our ſight.

It is thus we ſhould conſider the diſcoveries made by thoſe inſtruments, which have received their birth from an exertion of our faculties. It is to the ſame power, who created the objects of our admiration, that we are ultimately to refer the means of diſcovering them. Let no one, therefore, accuſe us of prying deeper into the wonders of nature, than was intended for us. There is nothing we diſcover by their aſſiſtance, which is not a freſh ſource of praiſe; and it does not appear, that our faculties can be better employed, than in finding means to inveſtigate the works of God.

From a partial conſideration of theſe things, we are very apt to criticiſe what we ought to admire; to look upon as uſeleſs what perhaps we ſhould own to be of infinite advantage to us, did we ſee a little farther; to be peeviſh where we ought to give thanks; and at the ſame time, to ridicule thoſe who employ their time and thoughts in examining what we were, i. e. ſome of us moſt aſſuredly were, created and appointed to ſtudy. In ſhort, we are too apt to treat the Almighty worſe than a rational man would treat a good mechanic, whoſe works he would either thoroughly examine, or be aſhamed to find any fault with them. This is the effect of a partial conſideration of nature; but he who has candor of mind, and leiſure to look farther, will be inclined to cry out:

How wond'rous is this ſcene! where all is form'd
With number, weight, and meaſure! all deſign'd

For ſome great end! where not alone the plant
Of ſtately growth; the herb of glorious hue,
Or food-full ſubſtance! not the laboring ſteed,
The herd, and flock that feed us; not the mine
That yields us ſtores for elegance and uſe;
The ſea that loads our table, and conveys
The wanderer man from clime to clime, with all
Thoſe rolling ſpheres, that from on high ſhed down
Their kindly influence; not theſe alone,
Which ſtrike ev'n eyes incurious, but each moſs,
Each ſhell, each crawling inſect, holds a rank
Important in the plan of Him, who fram'd
This ſcale of beings; holds a rank, which loſt
Would break the chain, and leave behind a gap
Which nature's ſelf would rue. Almighty Being,
Cauſe and ſupport of all things, can I view
Theſe objects of my wonder; can I feel
Theſe fine ſenſations, and not think of thee?
Thou who doſt thro 'th' eternal round of time,
Doſt thro' th' immenſity of ſpace exiſt
Alone, ſhalt thou alone excluded be
From this thy univerſe? Shall feeble man
Think it beneath his proud philoſophy
To call for thy aſſiſtance, and pretend
To frame a world, who cannot frame a clod?—
Not to know thee, is not to know ourſelves—
Is to know nothing—nothing worth the care
Of man's exalted ſpirit:—all becomes,
Without thy ray divine, one dreary gloom,
Where lurk the monſters of phantaſtic brains,

Order bereft of thought, uncaus'd effects,
Fate freely acting, and unerring chance.
Where meanleſs matter to a chaos ſinks,
Or ſomething lower ſtill, for without thee
It crumbles into atoms void of force,
Void of reſiſtance—it eludes our thought.
Where laws eternal to the varying code
Of ſelf-love dwindle. Intereſt, paſſion, whim,
Take place of right, and wrong, the golden chain
Of beings melts away, and the mind's eye
Sees nothing but the preſent. All beyond
Is viſionary gueſs—is dream—is death.*

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* Stillingfleet's Miſcellaneous Tracts.

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R. HINDMARSH,
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## CHAP. II.

### OF VISION, OF THE OPTICAL EFFECT OF MICROSCOPES, AND OF THE MANNER OF ESTIMATING THEIR MAGNIFYING POWERS.

THE progreſs that has been made in the ſcience of optics, in the laſt and preſent century, particularly by Sir Iſaac Newton, may with propriety be ranked among the greateſt acquiſitions of human knowledge. And Meſſ. Delaval and Herſchel have ſhewn by their diſcoveries, that the boundaries of this ſcience may be conſiderably enlarged.

The rays of light, which miniſter to the ſenſe of ſight, are the moſt wonderful and aſtoniſhing part of the inanimate creation; of which we ſhall ſoon be convinced, if we conſider their extreme minuteneſs, their inconceivable velocity, the regular variety of colours they exhibit, the invariable laws according to which they are acted upon by other ſubſtances, in their reflections, inflections, and refractions, without the leaſt change of their original properties; and the facility with which they pervade bodies of the greateſt denſity and cloſeſt texture, without reſiſtance, without crouding or diſturbing each other. Theſe, I believe, will be deemed ſufficient proofs of the wonderful nature of theſe rays; without adding, that it is by a peculiar modification of them, that we are indebted for the advantages we obtain by the microſcope.

The ſcience of optics, which explains and treats of many of the properties of theſe rays of light, is deduced from experiments, on which all philoſophers are agreed. It is impoſſible to give an adequate idea of the nature of viſion, without a knowledge of theſe experiments, and the mathematical reaſoning grounded upon them; but as to do this would alone fill a large volume, I ſhall only endeavour to render ſome of the more general principles clear, that the reader, who is unacquainted with the ſcience of optics, may nevertheleſs be enabled to comprehend the nature of viſion by the microſcope. Some of the moſt important of theſe principles may be deduced from the following very intereſting experiment.

Darken a room, and let the light be admitted therein only by a ſmall hole; then, if the weather is fine, you will ſee on the wall, which is facing the hole, a picture of all thoſe exterior objects which are oppoſite thereto, with all their colours, though theſe will be but faintly ſeen. The image of the objects that are ſtationary; as trees, houſes, &c. will appear fixed; while the images of thoſe that are in motion, will be ſeen to move. The image of every object will appear inverted, becauſe the rays croſs each other in paſſing through the ſmall hole. If the ſun ſhines on the hole, we ſhall ſee a luminous ray proceed in a ſtrait line, and terminate on the wall. If the eye is placed in this ray, it will be in a right line with the hole and the ſun: it is the ſame with every other object which is painted on the wall. The images of the objects exhibited on the ſame plane, are ſmaller in proportion as the objects are further from the hole.

Many and important are the inferences which may be deduced from the foregoing experiment, among which are the following:

1. That light flows in a right line.

2. That a luminous point may be ſeen from all thoſe places to which a ſtrait line can be drawn from the point, without meeting with any obſtacle; and conſequently

3. That a luminous point, by ſome unknown power, ſends forth rays of light in all directions, and is the center of a ſphere of light, which extends indefinitely on all ſides; and if we conceive ſome of theſe rays to be intercepted by a plane, then is the luminous point the ſummit of a pyramid, whoſe body is formed by the rays, and it's baſe by the intercepting plane.—The image of the ſurface of an object, which is painted on the wall, is alſo the baſe of a pyramid of light, the apex of which is the hole; the rays which form this pyramid, by croſſing at the hole, form another, ſimilar and oppoſite to this, of which the hole is alſo the ſummit, and the ſurface of the object the baſe.

4. That an object is viſible, becauſe all it's points are radiant points.

5. That the particles of light are indefinitely ſmall; for the rays, which proceed from the points of all the objects oppoſite to the hole, paſs through it, though extremely ſmall, without embarraſſing or confounding each other.

6. That every ray of light carries with it the image of the object from which it was emitted.

The nature of viſion in the eye, may be imperfectly illuſtrated by the experiment of the darkened room; the pupil of the eye being conſidered as the hole through which the rays of light paſs, and croſs each other, to paint on the retina, at the bottom of the eye, the inverted images of all thoſe objects which are expoſed to the ſight, ſo that the diameter of the images of the ſame object are greater, in proportion to the angles formed at the pupil, by the croſſing rays which proceed from the extremities of the object; that is, the diameter of the image is greater, in proportion as the diſtance is leſs; or, in other words, the apparent magnitude of an object is in ſome degree meaſured by the angle under which it is ſeen, and this angle increaſes or diminiſhes, according as the object is nearer to, or further from the eye; and conſequently, the leſs the diſtance is between the eye and the object, the larger the latter will appear.

From hence it follows, that the apparent diameter of an object ſeen by the naked eye, may be magnified in any proportion we pleaſe; for as the apparent diameter is increaſed, in proportion as the diſtance from the eye is leſſened, we have only to leſſen the diſtance of the object from the eye, in order to increaſe the apparent diameter thereof.* Thus, ſuppoſe there is an object, AB, Plate I. Fig. 1, which to an eye at E ſubtends or appears under the angle AEB, we may magnify the apparent diameter in what proportion we pleaſe, by bringing our eye nearer to it. If, for inſtance, we would magnify it in the proportion of FG to A B; that is, if we would ſee the object under an angle as large as F E G, or would make it appear the ſame length that an object as long as F G would appear, it may be done by coming nearer to the object. For the apparent diameter is as the diſtance inverſely; therefore, if C D is as much leſs than C E, as F G is greater than A B, by bringing the eye nearer to the object in the proportion of C D to E D, the apparent diameter will be magnified in the proportion of F G to A B; ſo that the object A B, to the eye at D, will appear as long as an object F G would appear to the eye at E. In the ſame manner, we might ſhew, that the apparent diameter of an object, when ſeen by the naked eye, may be infinite. For ſince the apparent diameter is reciprocally as the diſtance of the eye, when the diſtance of the eye is nothing, or when the eye is cloſe to the object at C, the apparent diameter will be the reciprocal of nothing, or infinite.

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* Rutherforth's Syſtem of Natural Philoſophy, p. 330.

There is, however, one great inconvenience in thus magnifying an object, without the help of glaſſes, by placing the eye nearer to it. The inconvenience is, that we cannot ſee an object diſtinctly, unleſs the eye is about five or ſix inches from it; therefore, if we bring it nearer to our eye than five or ſix inches, however it may be magnified, it will be ſeen confuſedly. Upon this account, the greateſt apparent magnitude of an object that we are uſed to, is the apparent magnitude, when the eye is about five or ſix inches from it: and we never place an object much within that diſtance; becauſe, though it might be magnified by this means, yet the confuſion would prevent our deriving any advantage from ſeeing it ſo large. The ſize of an object ſeems extraordinary, when viewed through a convex lens; not becauſe it is impoſſible to make it appear of the ſame ſize to the naked eye, but becauſe at the diſtance from the eye which would be neceſſary for this purpoſe, it would appear exceedingly confuſed; for which reaſon, we never bring our eye ſo near to it, and conſequently, as we have not been accuſtomed to ſee the object of this ſize, it appears an extraordinary one.

On account of the extreme minuteneſs of the atoms of light, it is clear, a ſingle ray, or even a ſmall number of rays, cannot make a ſenſible impreſſion on the organ of ſight, whoſe fibres are very groſs, when compared to theſe atoms; it is neceſſary, therefore, that a great number ſhould proceed from the ſurface of an object, to render it viſible. But as the rays of light, which proceed from an object, are continually diverging, different methods have been contrived, either of uniting them in a given point, or of ſeparating them at pleaſure: the manner of doing this, is the ſubject of dioptrics and catoptrics.

By the help of glaſſes, we unite in the ſame ſenſible point a great number of rays, proceeding from one point of an object; and as each ray carries with it the image of the point from whence it proceeded, all the rays united muſt form an image of the object from whence they were emitted. This image is brighter, in proportion as there are more rays united; and more diſtinct, in proportion as the order, in which they proceeded, is better preſerved in their union. This may be rendered evident; for, if a white and poliſhed plane is placed where the union is formed, we ſhall ſee the image of the object painted in all it's colours on this plane; which image will be brighter, if all adventitious light is excluded from the plane on which it is received.

The point of union of the rays of light, formed by means of a glaſs lens, &c. is called the FOCUS.

Now, as each ray carries with it the image of the object from whence it proceeded, it follows, that if thoſe rays, after interſecting each other, and having formed an image at their interſection, are again united by a refraction or reflection, they will form a new image, and that repeatedly, as long as their order is not confounded or diſturbed.

It follows alſo, that when the progreſs of the luminous ray is under conſideration, we may look on the image as the object, and the object as the image; and conſider the ſecond image, as if it had been produced by the firſt as an object, and ſo on.

In order to gain a clear idea of the wonderful effects produced by glaſſes, we muſt proceed to ſay ſomething of the principles of refraction.

Any body, which is ſo conſtituted as to yield a paſſage to the rays of light, is called a MEDIUM. Air, water, glaſs, &c. are mediums of light. If any medium affords an eaſy paſſage to the rays of light, it is called a RARE MEDIUM; but if it does not afford an eaſy paſſage to theſe rays, it is called a DENSE MEDIUM.

Let Z, Fig. 2, Plate I. be a rare medium, and Y a denſe one; and let them be ſeparated by the plane ſurface G H. Let I K be a perpendicular to it, and cutting it in C.

With the center C, and any diſtance, let a circle be deſcribed. Then let A C be a ray of light, falling upon the denſe medium. This ray, if nothing prevented, would go forward to L; but becauſe the medium Y is ſuppoſed to be denſer than Z, it will be bent downward toward the perpendicular I K, and deſcribe the line C B.

The ray A C is called the INCIDENT RAY; and the ray C B, the REFRACTED RAY.

The angle A C I is called the ANGLE OF INCIDENCE, and the angle B C K is called the ANGLE OF REFRACTION.

If from the point A, upon the right line C I, there be let fall the perpendicular A D, that line is called the ſine of the angle of incidence.

In the ſame manner, if from the point B, upon the right line I K, there be let fall the perpendicular B E, that line will be the ſine of the angle of refraction.

The ſines of the angles are the meaſures of the refractions, and this meaſure is conſtant; that is, whatever is the ſine of the angle of incidence, it will be in a conſtant proportion to the ſine of the angle of refraction, when the mediums continue the ſame. A general idea of refraction may be formed from the following experiments.

Let A B C D, Fig. 3, Plate I. repreſent a veſſel ſo placed, with reſpect to the candle E, that the ſhadow of the ſide A C may fall at D. Suppoſe the veſſel to be now filled with water, and the ſhadow will withdraw to d; the ray of light, inſtead of proceeding to D, being refracted or bent to d. And there is no doubt but that an eye, placed at d, would ſee the candle at e, in the direction of the refracted ray d A. This is alſo confirmed by the following pleaſing experiment.

Lay a ſhilling, or any piece of money, at the bottom of a baſon; then withdraw from the baſon, till you loſe ſight of the ſhilling; fill the baſon nearly with water, and the ſhilling will be ſeen very plainly, though you are at the ſame diſtance from it.

Experiment 3. Place a ſtick over a baſon which is filled with water; then reflect the ſun's rays, ſo that they may fall perpendicularly on the ſurface of the water; the ſhadow of the ſtick will fall on the ſame place, whether the veſſel be empty or full.

What has been ſaid of water, may be applied to any tranſparent medium, only the power of refraction is greater in ſome than in others. It is from this wonderful property, that we derive all the curious effects of glaſs, which make it the ſubject of optics. It is to this we owe the powers of the microſcope and the teleſcope.

To produce theſe effects, pieces of glaſs are formed into given figures, which, when ſo formed, are called lenſes. The ſix under-mentioned figures, are thoſe which are moſt in uſe for optical purpoſes.

1. A PLANE GLASS, one that is flat on each ſide, and of an equal thickneſs throughout. F, Fig. 13, Plate I.

2. A DOUBLE CONVEX GLASS, one that is more elevated towards the middle than the edge. B, Fig. 13, Plate I.

3. A DOUBLE CONCAVE is hollow on both ſides, or thinner in the middle than at the edges. D, Fig. 13, Plate I.

4. A PLANO CONVEX, flat on one ſide, and convex on the other. A, Fig. 13, Plate I.

5. A PLANO CONCAVE, flat on one ſide, and concave on the other. C, Fig. 13, Plate I.

6. A MENISCUS, convex on one ſide, concave on the other. E, Fig. 13, Plate I.

It has been already obſerved, that light proceeds invariably from a luminous body, in ſtrait lines, without the leaſt deviation; but if it happen to paſs from one medium to another, it always leaves the direction it had before, and aſſumes a new one. After having taken this new direction, it proceeds in a ſtrait line, till it meets with a different medium, which again turns it out of it's courſe.

A ray of light, paſſing obliquely through a plane glaſs, will go out in the ſame direction it entered, though not preciſely in the ſame line. The ray CD, Fig. 4, Plate I. falling obliquely upon the ſurface of the plane glaſs A B, will be refracted towards the glaſs in the direction D E; but when it comes to E, it will be as much refracted the contrary way. If the ray of light had fallen perpendicularly on the ſurface of the plane glaſs, it would have paſſed through it in a ſtrait line, and not have been refracted at all.

If parallel rays of light, as a b c d e f g, Fig. 6, Plate I. fall directly upon a convex lens A B, they will be ſo bent, as to unite in a point C behind it. For the ray d D, which falls perpendicularly upon the middle of the glaſs, will go through it without ſuffering any refraction: but thoſe which go through the ſides of the lens, falling obliquely on it's ſurface, will be ſo bent, as to meet the central ray at C. The further the ray a is from the axis of the lens, the more obliquely it will fall upon it. The rays a b c d e f g will be ſo refracted, as to meet or be collected in the point F, called the principal focus, whoſe diſtance, in a double convex lens, is equal to the radius or ſemi-diameter of the ſphere of the convexity of the lens. All the rays croſs the middle ray at C, and then diverge from it to the contrary ſide, in the ſame manner as they were before converged.

If another lens, of the ſame convexity, as A B, Fig. 6, Plate I. be placed in the rays, and at the ſame diſtance from the focus, it will refract them, ſo that after going out of it, they will all be parallel again, and go on in the ſame manner as they came to the firſt glaſs A B, but on the contrary ſides of the middle ray.

The rays diverge from any radiant point, as from a principal focus: therefore, if a candle be placed at C, in the focus of the convex lens A B, Fig. 6, Plate I. the rays diverging from it will be ſo refracted by the lens, that after going out of it, they will become parallel. If the candle be placed nearer the lens than it's focal diſtance, the rays will diverge more or leſs, as the candle is more or leſs diſtant from the focus.

If any object, A B, Fig. 7, Plate I. be placed beyond the focus of the convex lens E F, ſome of the rays which flow from every point of the object, on the ſide next the glaſs, will fall upon it, and after paſſing through it, they will be converged into as many points on the oppoſite ſide of the glaſs; for the rays a b, which flow from the point A, will converge into *a b*, and meet at C. The rays c d, flowing from the point G, will be converged into *c d*, and meet at g; and the rays which flow from B, will meet each other again at D; and ſo of the rays which flow from any of the intermediate points: for there will be as many focal points formed, as there are radiant points in the object, and conſequently they will paint on a ſheet of paper, or any other light-coloured body, placed at D g c, an inverted image of the object. If the object is brought nearer the lens, the picture will be formed further off. If it be placed at the principal focus, the rays will go out parallel, and conſequently form no picture behind the glaſs.

The human eye is ſo conſtituted, that it can only have diſtinct viſion, when the rays which fall on it are parallel, or nearly ſo; becauſe the retina, on which the image is painted, is placed in the focus of the cryſtalline humor, which performs the office of a lens in collecting rays, and forming the image in the bottom of the eye.

The picture, formed by a convex lens, is either larger or leſs than the object, in proportion as it's diſtance from the lens is greater or leſs than it's diſtance from the object.

As an object becomes perceptible to us, by means of the image thereof which is formed on the retina, it will, therefore, be ſeen in that direction, in which the rays enter the eye to form the image, and will always be found in the line, in which the axis of a pencil of rays flowing from it enter the eye. We from hence acquire a habit of judging the object to be ſituated in that line. Note; as the mind is unacquainted with the refraction the rays ſuffer before they enter the eye, it judges them to be in the line produced back, in which the axis of a pencil of rays flowing from it is ſituated, and not in that in which it was before the refraction.

If the rays, therefore, that proceed from an object, are refracted and reflected ſeveral times before they enter the eye, and theſe refractions, or reflections, change conſiderably the original direction of the rays which proceed from the object; it is clear, that it will not be ſeen in that line, which would come ſtrait from it to the eye; but it will be ſeen in the direction of thoſe rays which enter the eye, and form the image thereof on it.

We perceive the preſence and figure of objects, by the impreſſion each reſpective image makes on the retina; the mind, in conſequence of theſe impreſſions, forms concluſions concerning the ſize, poſition, and motion of the object. It muſt however be obſerved, that theſe concluſions are often rectified or changed by the mind, in conſequence of the effects of more habitual impreſſions. For example; there is a certain diſtance, at which, in the general buſineſs of life, we are accuſtomed to ſee objects: now, though the meaſure of the image of theſe objects changes conſiderably when they move from, or approach nearer to us, yet we do not perceive that their ſize is much altered: but beyond this diſtance, we find the objects appear to be diminiſhed, or increaſed, in proportion as they are more or leſs diſtant from us.

For inſtance, if I place my eye ſucceſſively at two, at four, and at ſix feet from the ſame perſon, the dimenſions of the image on the retina will be nearly in the proportion of 1, of $\frac{1}{2}$, of $\frac{1}{3}$, and conſequently they ſhould appear to be diminiſhed in the ſame proportion; but we do not perceive this diminution, becauſe the mind has rectified the impreſſion received on the retina. To prove this, we need only conſider, that if we ſee a perſon at 120 feet diſtance, he will not appear ſo ſtrikingly ſmall, as if the ſame perſon ſhould be viewed from the top of a tower, or other building, 120 feet high, a ſituation to which we had not been accuſtomed.

From hence, alſo, it is clear, that when we place a glaſs between the object and the eye, which from it's figure changes the direction of the rays of light from the object, this object ought not to be judged as if it were placed at the ordinary reach of the ſight, in which caſe we judge of it's ſize more by habit than by the dimenſions of the images formed on the retina: but it muſt be eſtimated by the ſize of the image in the eye, or by the angle formed at the eye, by the two rays which come from the extremity of the object.

If the image of an object, formed after refraction, is greater or leſs than the angle formed at the eye, by the rays proceeding from the extremities of the object itſelf, the object will appear alſo proportionably enlarged or diminiſhed; ſo that if the eye approaches to, or removes from, the laſt image, the object will appear to increaſe or diminiſh, though the eye ſhould in reality remove from it in one caſe, or approach towards it in the other; becauſe the image takes place of the object, and is conſidered inſtead of it.

The apparent diſtance of an object from the eye, is not meaſured by the real diſtance from the laſt image; for, as the apparent diſtance is eſtimated principally by the ideas we have of their ſize, it follows, that when we ſee objects, whoſe images are increaſed or diminiſhed by refraction, we naturally judge them to be nearer or further from the eye, in proportion to the ſize thereof, when compared to that with which we are acquainted. The apparent diſtance of an object is conſiderably affected by the brightneſs, diſtinctneſs, and magnitude thereof. Now as theſe circumſtances are, in a certain degree, altered by the refraction of the rays, in their paſſing through different mediums, they will alſo, in ſome meaſure, affect the eſtimation of the apparent diſtance.

In the theory of viſion, it is neceſſary to be cautious not to confound the organs of viſion with the being that perceives, or with the perceptive faculty. The eye is not that which ſees, it is only the organ by which we ſee. A man cannot ſee the ſatellites of Jupiter but by a teleſcope. Does he conclude from this, that it is the teleſcope that ſees thoſe ſtars? By no means; ſuch a concluſion would be abſurd. It is no leſs abſurd to conclude, that it is the eye that ſees. The teleſcope is an artificial organ of ſight, but it ſees not. The eye is a natural organ of ſight, by which we ſee; but the natural organ ſees as little as the artificial.

The eye is a machine, moſt admirably contrived for refracting the rays of light, and forming a diſtinct picture of objects upon the retina; but it ſees neither the object nor the picture. It can form the picture after it is taken out of the head, but no viſion enſues. Even when it is in it's proper place, and perfectly ſound, it is well known, that an obſtruction in the optic nerve takes away viſion, though the eye has performed all that belongs to it.*

For uſeleſs was this textur'd † wonder made,
Were nature, beauteous object! undiſplayed;
Thoſe both in vain, the object and the ſight,
Wrapt from the radiance of revealing light;
As vain the bright illuminating beam,
Unwafted by the medium's airy ſtream:
Yet vain the textur'd eye, and object fair,
The ſunny luſtre, and continuous air;
Annull'd and blank this grand illuſtrious ſcene,
All, all it's grace and lifeleſs glories vain;
Till from th' ETERNAL ſprung this effluent ſoul,
Form'd to inſpect, and comprehend the whole.‡

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* Reid on the Intellectual Powers of Man, p. 78.

† The eye.

‡ Brooke's Univerſal Beauty, p. 88.

## OF THE SINGLE MICROSCOPE.

The ſingle microſcope renders minute objects viſible, by means of a ſmall glaſs globule, or convex lens, of a ſhort focus. Let E Y, Fig. 11, Plate I. repreſent the eye; and O B, a ſmall object, ſituated very near to it, conſequently the angle of it's apparent magnitude very large. Let the convex lens R S be interpoſed between the eye and the object, ſo that the diſtance between it and the object may be equal to the focal length; and the rays which diverge from the object, and paſs through the lens, will afterwards proceed, and conſequently enter the eye parallel: after which, they will be converged, and form an inverted picture on the retina, and the object will be clearly ſeen; though, if removed to the diſtance of ſix inches, it's ſmallneſs would render it inviſible.

When the lens is not held cloſe to the eye, the object is ſomewhat more magnified; becauſe the pencils, which paſs at a diſtance from the center of the lens, are refracted inward toward the axis, and conſequently ſeem to come from points more remote from the center of the object, as may be ſeen in Fig. 12, Plate I. where the pencils which proceed from O and B are refracted inwards, and ſeem to come from the point i and m.

Fig. 8, Plate I. may, perhaps, give the reader a ſtill clearer view, why a convex lens increaſes the angle of viſion. Without a lens, as F G, the eye at A would ſee the dart B C under the angle b A c; but the rays B F and C G from the extremities of the dart in paſſing through the lens, are refracted to the eye in the directions f A and G a, which cauſes the dart to be ſeen under the much larger angle D A E (the ſame as the angle f A g). And therefore, the dart B C will appear ſo much magnified, as to extend in length from D to E.

The object, when thus ſeen diſtinctly, by means of the ſmall lens, appears to be magnified nearly in the proportion which the focal diſtance of the glaſs bears to the diſtance of the objects, when viewed by the naked eye.

To explain this further, place the eye cloſe to the glaſs, that as much of the object may be ſeen at one view as is poſſible; then remove the object to and fro, till it appears perfectly diſtinct, and well defined; now remove the lens, and ſubſtitute in it's place a thin plate, with a very ſmall hole in it, and the object will appear as diſtinct, and as much magnified, as with the lens, though not quite ſo bright; and it appears as much more magnified in this caſe, than it does when viewed with the naked eye, as the diſtance of the object from the hole, or lens, is leſs than the diſtance at which it may be ſeen diſtinctly with the naked eye.

From hence we ſee, that the whole effect of the lens is to render the object diſtinct, which it does by aſſiſting the eye to increaſe the refraction of the rays in each pencil; and that the apparent magnitude is entirely owing to the object being ſeen ſo much nearer the eye than it could be viewed without it.

Single microſcopes magnify the diameter of the object, * as we have already ſhewn, in the proportion of the focal diſtance (to the limits

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* Cyclopedia art microſcope.

limits of diſtinct viſion with the naked eye) to eight inches. For example, if the ſemi-diameter of a lens, equally convex on both ſides, be half an inch, which is alſo equal to it's focal diſtance, we ſhall have as $\frac{1}{2}$ is to 8, ſo is 1 to 16; that is, the diameter of the object in the proportion of ſixteen to one. 2. As the diſtance of eight inches is always the ſame, it follows, that by how much the focal diſtance is ſmaller, there will be a greater difference between it and the eight inches; and conſequently, the diameter of the object will be ſo much the more magnified, in proportion as the lenſes are ſegments of ſmaller ſpheres. 3. If the object be placed in the focus of a glaſs globule or ſphere, and the eye be behind it in the focus, the object will be ſeen diſtinct in an erect ſituation, and magnified as to it's diameter, in the proportion of $\frac{3}{4}$ of the diameter of the globule to eight inches; thus ſuppoſe the diameter of the ſphere to be $\frac{1}{10}$ of an inch, then $\frac{3}{4}$ of this will be equal to $\frac{3}{40}$; conſequently, the real diameter of the object to the apparent one, as $\frac{3}{40}$ to 8, or as 3 to 320, or as 1 to 160 nearly.

## OF THE DOUBLE OR COMPOUND MICROSCOPE.

In the compound microſcope, the image is viewed inſtead of the object, which image is magnified by a ſingle lens, as the object is in a ſingle microſcope. It conſiſts of an object lens, L N, Fig. 5, Plate I. and an eye glaſs F G. The object O B is placed a little further from the lens than it's principal focal diſtance, ſo that the pencils of rays proceeding from the different points of the object through the lens, may converge to their reſpective foci, and form an inverted image of the object at P Q; which image is viewed by the eye through the eye glaſs F G, which is ſo placed, that the image may be in it's focus on one ſide, and the eye at the ſame diſtance on the other. The rays of each pencil will be parallel, after paſſing out of the glaſs, till they reach the eye at E, where they will begin to converge by the refractive powers of the humours; and after having croſſed each other in the pupil, and paſſed through the chryſtalline and vitreous humours, they will be collected in points on the retina, and form a large inverted image thereon.

It will be eaſy, from what has been already explained, to underſtand the reaſon of the magnifying power of a compound microſcope. The object is magnified upon two accounts; firſt, becauſe if we viewed the image with the naked eye, it would appear as much larger than the object, as the image is really larger than it, or as the diſtance f R is greater than the diſtance f b; and ſecondly, becauſe this picture is again magnified by the eye glaſs, upon the principle explained in the foregoing article on viſion, by ſingle microſcopes.

But it is to be noted, that the image formed in the focus of a lens, as is the caſe in the compound microſcope, differs from the real object in a very eſſential particular; that is to ſay, the light being emitted from the object in every direction, renders it viſible to an eye placed in any poſition; but the points of the image formed by a lens, emitting no more than a ſmall conical body of rays, which arrives from the glaſs, can be viſible only when the eye is ſituate within it's confine. Thus the pencil, which emanates from o in the object, and is converged by the lens to M, proceeds afterwards diverging towards H, and therefore, never arrives at the lens F G, nor enters the eye at E. But the pencils which proceed from the points o and b, will be received on the lens F G, and by it carried parallel to the eye; conſequently, the correſpondent points of the image Q P will be viſible; and thoſe which are ſituate farther out towards H and I, will not be ſeen. This quantity of the image Q P, or viſible area, is called the field of view.

Hence it appears, that if the image be large, a very ſmall part of it will be viſible; becauſe the pencils of rays will for the moſt part fall without the eye glaſs F G. And it is likewiſe plain, that a remedy which would cauſe the pencils, which proceed from the extremes O and B of the object, to arrive at the eye, will render a greater part of it viſible; or, in other words, enlarge the field of view. This is effected by the interpoſition of a broad lens D E (Fig. 5,) of a proper curvature, at a ſmall diſtance from the focal image. For, by that means, the pencil D M, which would otherwiſe have proceeded towards H, is refracted to the eye, as delineated in the figure, and the mind conceives from thence the exiſtence of a radiant point at Q, from which the rays laſt proceeded. In like manner, and by a parity of reaſon, the other extreme of the image is ſeen at P, and the intermediate points are alſo rendered viſible. On theſe conſiderations it is, that compound microſcopes are uſually made to conſiſt of an object lens L N, by which the image is formed, enlarged, and inverted; an amplifying lens D E, by which the field of view is enlarged, and an eye glaſs or lens, by means of which the eye is allowed to approach very near, and conſequently to view the image under a very great angle of apparent magnitude. It is now cuſtomary to combine two or more lenſes together at the eye glaſs, in the manner of Euſtachio Divini and M. Joblot; by which means, the aberration of light from the figure is in ſome meaſure corrected, and the apparent field increaſed.

## Of the Solar Microscope.

In this inſtrument, the image of the object is thrown upon a ſcreen in a darkened room. It may be conſidered under two diſtinct heads: 1ſt, the mirror and lens, which are intended to reflect the light of the ſun upon the object; and 2dly, that part which conſtitutes the microſcope, or which produces the magnified image of the object, Fig. 10, Plate I. Let N O repreſent the ſide of a darkened chamber, G H a ſmall convex lens, fixed oppoſite to a perforation in the ſide N O, A B a plane mirror, or looking-glaſs, placed without the room to reflect the ſolar rays on the lens C D, by which they are converged and concentrated on the object fixed at E F.

2. The object being thus illuminated, the ray which proceeds from E will be converged by the lens G H to a focus K, on the ſcreen L M; and the ray which comes from F will be converged to I, and the intermediate points will be delineated between I and K; thus forming a picture, which will be as much larger than the object, in proportion as the diſtance of the ſcreen exceeds that of the image from the object.

From what has been ſaid, it appears plainly, the advantages we gain by microſcopes are derived, firſt, from their magnifying power, by which the eye is enabled to view more diſtinctly the parts of minute objects: ſecondly, that by their aſſiſtance, more light is thrown into the pupil of the eye, than is done without them. The advantages procured by the magnifying power, would be exceedingly circumſcribed, if they were not accompanied by the latter: for if the ſame quantity of light is diffuſed over a much larger ſurface, it's force is proportionably diminiſhed; and therefore the object, though magnified, will be dark and obſcure. Thus, ſuppoſe the diameter of the object to be enlarged ten times, and conſequently the ſurface one hundred times, yet, if the focal diſtance of the glaſs was eight inches, (provided this was poſſible) and it's diameter only about the ſize of the pupil of the eye, the object would appear one hundred times more obſcure when viewed through the glaſs, than when it was ſeen by the naked eye; and this even on the ſuppoſition, that the glaſs tranſmitted all the light which fell upon it, which no glaſs can do. But if the glaſs was only four inches focal diſtance, and it's diameter remained as before, the inconvenience would be vaſtly diminiſhed; becauſe the glaſs could be placed twice as near the object as before, and would conſequently receive four times as many rays as in the former caſe, and we ſhould therefore ſee it much brighter than before. By going on thus, diminiſhing the focal diſtance of the glaſs, and keeping it's diameter as large as poſſible, we ſhall perceive the object proportionably magnified, and yet remain bright and diſtinct. Though this is the caſe in theory, yet there is a limit in optical inſtruments, which is ſoon arrived at, but which cannot be paſſed. This ariſes from the following circumſtances.*

1. The quantity of light loſt in paſſing through the glaſs.

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* Encyclopedia Britannica, vol. viii. p. 5635.

2. The diminution in the diameter of the glaſs or lens itſelf, by which it receives only a ſmall quantity of rays.

3. The extreme ſhortneſs of the focal diſtance of great magnifiers, whereby the free acceſs of the light to the object we wiſh to view is impeded, and conſequently the reflection of the light from it is weakened.

4. The aberration of the rays, occaſioned by their different refrangibility.

To make this more clear, let us ſuppoſe a lens made of ſuch dull kind of glaſs, that it tranſmits only one half the light that falls upon it. It is evident, that ſuppoſing this lens to be of four inches focus, and to magnify the diameter of the object twice, and it's own breadth equal to that of the pupil of the eye, the object will be four times magnified in ſurface, but only half as bright as if it was ſeen by the naked eye at the uſual diſtance; for the light which falls upon the eye from the object at eight inches diſtance, and likewiſe the ſurface of the object in it's natural ſize, being both repreſented by 1, the ſurface of the magnified object will be 4, and the light which makes it viſible only 2; becauſe though the glaſs receives four times as much light as the naked eye does at the uſual diſtance of diſtinct viſion, yet one half is loſt in paſſing through the glaſs. The inconvenience, in this reſpect, can only be removed ſo far as it is poſſible to increaſe the tranſparency of the glaſs, that it may tranſmit nearly all the rays which fall upon it; and how far this can be done, has not been yet aſcertained.

The ſecond obſtacle to the perfection of microſcopic glaſſes, is the ſmall ſize of great magnifiers; by which means, notwithſtanding their near approach to the object, they receive a ſmaller quantity of light than might be expected. Thus, ſuppoſe a glaſs of only one-tenth of an inch focal diſtance, ſuch a glaſs would increaſe the viſible diameter eighty times, and the ſurface 6400 times. If the breadth of the glaſs could at the ſame time be preſerved as great as the pupil of the eye, which we ſhall ſuppoſe one-tenth of an inch, the object would appear magnified 6400 times, and every part would be as bright as it appears to the naked eye. But if we ſuppoſe the lens to be only $\frac{1}{20}$ of an inch diameter, it will then only receive $\frac{1}{4}$ of the light which would otherwiſe have fallen upon it; therefore, inſtead of communicating to the magnified object a quantity of light equal to 6400, it would communicate an illumination ſuited only to 1600, and the magnified object would appear four times as dim as it does to the naked eye. This inconvenience can, however, be in a great degree removed, by throwing a much larger quantity of light on the object. Various methods of effecting this purpoſe will be pointed out in the courſe of the work.

The third obſtacle ariſes from the ſhortneſs of the focal diſtance in large magnifiers; this inconvenience can, like the former, be remedied in ſome degree by artificial means of accumulating light; but ſtill the eye is ſo ſtrained, as it muſt be brought nearer the glaſs than it can well bear, which in ſome meaſure ſuperſedes the uſe of very deep lenſes, or ſuch as are capable of magnifying beyond a certain degree.

The fourth obſtacle which ariſes from the different refrangibility of the rays of light, and which frequently cauſes ſuch deviations from truth in the appearance of things, that many have imagined themſelves to have made ſurprizing diſcoveries, and have communicated them as ſuch to the world; when, in fact, they have been only optical deceptions, owing to the unequal refraction of the rays. In teleſcopes, this error has been happily corrected by Mr. Dollond's valuable diſcovery of achromatic glaſſes; but how far this invention is applicable to the improvement of microſcopes, has not yet been aſcertained; and indeed there is ſome reaſon for ſuppoſing, they cannot be ſucceſsfully applied to them; ſo that this obſtacle remains yet to be remedied, before microſcopes can be ſaid to have received their ultimate degree of perfection.

## OF THE MAGNIFYING POWERS OF THE MICROSCOPE.

We have already treated of the apparent magnitude of objects, and ſhewn that they are meaſured by the angles under which they are ſeen, and that this angle is greater or ſmaller, according as the object is nearer to, or further from, the eye; and conſequently, the leſs the diſtance at which it can be viewed, the larger it will appear: but from the limits of natural viſion, the naked eye cannot diſtinguiſh an object that is very near to it; yet, when aſſiſted by a convex lens, diſtinct viſion is obtained, however ſhort the focus of the lens, and conſequently, how near ſoever the object is to the eye; and the ſhorter the focus of the lens is, the greater will be the magnifying power thereof. From theſe conſiderations, it will not be difficult to eſtimate the magnifying power of any lens uſed as a ſingle microſcope; for this will be in the ſame proportion that the limits of natural ſight bear to the focus of the lens. If, for inſtance, the convex lens is of one inch focus, and the natural ſight of eight inches, an object ſeen through that lens will have it's diameter apparently increaſed eight times; but as the object is increaſed in every direction, we muſt ſquare this apparent diameter, to know how much the object is really magnified; and thus multiplying 8 by 8, we find the ſuperficies is magnified 64 times.

From theſe principles, the following general rule for aſcertaining the magnifying power of ſingle lenſes, is deduced. Place a ſmall thin tranſparent object on the ſtage of the microſcope, adjuſt the lens till the object appears perfectly diſtinct, then meaſure the diſtance accurately between the lens and the object, reduce the meaſure thus found to the hundredths of an inch, and calculate how many times this meaſure is contained in eight inches, firſt reducing the eight inches into hundredths, which will give you the number of times the diameter of the object is magnified; which number multiplied into itſelf, or ſquared, gives the apparent ſuperficial magnitude of the object.

As only one ſide of an object can be viewed at a time, it is ſufficient, in general, to know how much the ſurface thereof is magnified: but when it is neceſſary to know how many minute objects are contained in a larger, as for inſtance, how many given animalcula are contained in the bulk of a grain of ſand, then we muſt cube the firſt number, by which means we ſhall obtain the ſolidity or magnified bulk.

The foregoing rule has been alſo applied to eſtimate the magnifying power of the compound microſcope. To this application, Mr. Magny, in the "Journal d'Economie pour les mois d'Aout 1753," has made ſeveral objections: one or two of theſe I ſhall juſt mention: the firſt is the difficulty of aſcertaining with accuracy the preciſe focus of a ſmall lens; the ſecond is the want of a fixed or known meaſure, with which to compare the focus when aſcertained. Theſe conſiderations, though apparently trifling, will be found of importance in the calculations which are relative to deep magnifiers. To this it may be further added, that the ſame ſtandard or fixed meaſure cannot be aſſumed for a ſhort-ſighted, that is, uſed for a well-conſtituted eye. To obviate theſe difficulties, and ſome errors in the methods which were recommended by Meſſ. Baker and Needham, Mr. Magny offers the following

## PROPOSITION.

All convex lenſes, of whatſoever focus, double the apparent diameter of an object, provided that the object is at the focus of the glaſs on one ſide, and the eye is at the ſame diſtance, or on the focus of the glaſs, at the oppoſite ſide.

## EXPERIMENT.

Take a double convex lens, of ſix or eight inches focus, and fix it as at A, Fig. 1, (Plate II. A,) into the piece A, which is fixed perpendicular to the rule F G, and may be ſlid along it by means of it's ſocket: the rule is divided into inches and parts. Paſte a piece of white paper, two or three tenths of an inch broad, and three inches long, on the board D; draw three lines with ink on this piece of paper, ſo as to divide it into four equal parts, taking care that the middle of the paper correſponds with the center of the lens. There is alſo a ſliding eye-piece, which is repreſented at e.

Take this apparatus into the darkeſt part of the room, but oppoſite to the window; direct the glaſs towards any remarkable and diſtant object which is out of doors, and move the ſliding piece B, until the image of the object on the paper is ſharp and clear. The diſtance between the face of the paper and the lens, (which is ſhewn on the ſide of the rule by the diviſions thereon) is the focus of the glaſs; now ſet the eye-piece e E to the ſame diſtance on the other ſide of the glaſs, then with one eye cloſe to the ſight at e, look at the magnified image of the lines, and with the other eye at the lines themſelves: the image, ſeen by means of the glaſs, and expreſſed in the figure by the dotted lines, will be double the breadth of the ſame object ſeen by the natural eye. This will be found to be true, whatſoever is the focus of the lens with which the experiment is made.

This experiment is rendered more ſimple to thoſe who are not accuſtomed to obſerve with both eyes at the ſame time, by making uſe of half a lens, and placing the diameter perpendicular to the rule, as they may then readily view the magnified image and real object with the ſame glance of the eye, and thus compare them together with eaſe and accuracy.

Let the angle A F B, Fig. 3, Plate II. A, repreſent that which is formed at the naked eye, by the rays of light which paſs from the extremities of the object, and unite at the eye in the point F. The angle D F E is ſormed of the two rays, which at firſt proceeded parallel to each other from the extremities of the object, but that were afterwards ſo refracted, or bent, by paſſing through the glaſs, as to unite at it's focal point F. C O is equal to the focal diſtance of the lens on the ſide next the object, C F equal thereto on the ſide next the eye, F O the diſtance of the eye.

From the allowed principles of optics, it is evident, that the object would appear double the ſize to the eye at C, that it would to the eye when placed at F; becauſe the diſtance F O is double the diſtance C O. We have only to prove then, that the angle A C B is equal to the angle I F K, in order to eſtabliſh the propoſition.

The optical axis is perpendicular to the glaſs and the ſurface of the object. The rays A I, B K, which flow from the points A B, are parallel to each other, and perpendicular to the glaſs, till they arrive at it; they are then refracted, and proceed to F, where they form the triangle I F K, reſting on the baſe I K: now as C F is equal to C O, and I K is equal to A B, the two triangles ACB IFK are ſimilar, and conſequently the angle at C is equal to the angle F. If the viſual rays are continued to the ſurface of the object, they will form the triangle D F E, equiangled to the triangle A B C; and therefore, as C O is to A B, ſo is F D to D E; and conſequently, the apparent diameter of the object ſeen through the lens, is double the ſize that it is when viewed by the naked eye. No notice is here taken of the double refraction of the rays, as it does not affect the demonſtration.

If you advance towards M, half the focal diſtance, the apparent diameter will be only increaſed one-third. If, on the contrary, the point of ſight is lengthened to double the diſtance of it's focus, then the magnified diameter will appear to be three times that of the real object. Mr. Magny concludes from hence, that there is an impropriety in eſtimating the magnifying power of the eye glaſs of compound microſcopes, by ſeeing how often it's focus is contained in eight or ten inches; and to obviate theſe defects, he recommends two methods to be uſed, which reciprocally confirm each other.

The firſt and moſt ſimple method to find how much any compound microſcope magnifies an object, is the ſame which is deſcribed by Dr. Hooke in his Micrographia, and is as follows: place an accurate ſcale, which is divided into very minute parts of an inch, on the ſtage of your microſcope; adjuſt the microſcope, till theſe diviſions appear diſtinct; then obſerve with the other eye how many diviſions of a rule, ſimilarly divided and held at the ſtage, are included in one of the magnified diviſions: for if one diviſion, as ſeen with one eye through the microſcope, extends to thirty diviſions on the rule, which is ſeen by the naked eye, it is evident, that the diameter of the object is increaſed or magnified thirty times.

For this purpoſe, we often uſe a ſmall black ebony rule, (ſee Fig. 4, Plate II. A,) three or four tenths of an inch broad, and about ſeven inches long; at each inch is fixed a piece of ivory, the firſt inch is entirely of ivory, and ſubdivided into ten equal parts.

2. A piece of glaſs, Fig. 2, fixed in a braſs or ivory ſlider; on the diameter of this are drawn two parallel lines, about three-tenths of an inch long; each tenth being divided, one into three, the ſecond into four, the third into five parts. To uſe this, place the glaſs, Fig. 2, on the middle of the ſtage, and the rule, Fig. 4, on one ſide, but parallel to it; then look into the microſcope with one eye, keeping the other open, and obſerve how many parts one-tenth of a line in the microſcope takes in upon the parts of the rule ſeen by the naked eye. For inſtance, ſuppoſe with a fourth magnifier, that one-tenth of an inch magnified anſwers in length to forty tenths or parts on the rule, when ſeen by the naked eye, then this magnifier increaſes the diameter of the object forty times.

This mode of actual admeaſurement is, without doubt, the moſt ſimple that can be uſed; by it we comprehend, as it were, at one glance, the different effects of combined glaſſes; it ſaves the trouble, and avoids the obſcurity that attends the uſual modes of calculation; but many perſons find it exceedingly difficult to adopt this method, becauſe they have not been accuſtomed to obſerve with both eyes at once. We ſhall therefore proceed to deſcribe another method, which has not this inconvenience.

## OF THE NEEDLE MICROMETER.

Fig. 8, Plate II. A, repreſents this micrometer. The firſt of this kind was made by my father, and was deſcribed by him in his Micrographia Illuſtrata. It conſiſts of a ſcrew, which has fifty threads to an inch; this ſcrew carries an index, which points to the diviſions on a circular plate, which is fixed at right angles to the axis of the ſcrew. The revolutions of the ſcrew are counted on a ſcale, which is an inch divided into fifty parts; the index to theſe diviſions is, a flower de luce marked upon the ſlider, which carries the needle point acroſs the field of the microſcope. Every revolution of the micrometer ſcrew meaſures $\frac{1}{50}$ part of an inch, which is again ſubdivided by means of the diviſions on the circular plate, as this is divided into twenty equal parts, over which the index paſſes at every revolution of the ſcrew; by which means, we obtain with eaſe the meaſure of one thouſandth part of an inch: for 50, the number of threads on the ſcrew in one inch, being multiplied by 20 the diviſions on the circular plate, are equal to 1000; ſo that each diviſion on the circular plate ſhews, that the needle has either advanced or receded one thouſandth part of an inch.

To place this micrometer on the body of the microſcope, open the circular part F K H, Fig. 8, Plate II. A, by taking out the ſcrew G, throw back the ſemicircle F K which moves upon a joint at K, then turn the ſliding tube of the body of the microſcope, ſo that the ſmall holes which are in both tubes may exactly coincide, and let the needle g of the micrometer have a free paſſage through them; after this, ſcrew it faſt upon the body by the ſcrew G.

The needle will now traverſe the field of the microſcope, and meaſure the length and breadth of the image of any object that is applied to it. But further aſſiſtance muſt be had, in order to meaſure the object itſelf, which is a ſubject of real importance; for though we have aſcertained the power of the microſcope, and know that it is ſo many thouſand times, yet this will be of little aſſiſtance towards aſcertaining an accurate idea of it's real ſize; for our ideas of bulk being formed by the compariſon of one object with another, we can only judge of that of any particular body, by comparing it with another whoſe ſize is known: the ſame thing is neceſſary, in order to form an eſtimate by the microſcope; therefore, to aſcertain the real meaſure of the object, we muſt make the point of the needle paſs over the image of a known part of an inch placed on the ſtage, and write down the revolutions made by the ſcrew, while the needle paſſed over the image of this known meaſure; by which means, we aſcertain the number of revolutions on the ſcrew, which are adequate to a real and known meaſure on the ſtage. As it requires an attentive eye to watch the motion of the needle point, as it paſſes over the image of a known part of an inch on the ſtage, we ought not to truſt to one ſingle meaſurement of the image, but ought to repeat it at leaſt ſix times; then add the ſix meaſures thus obtained together, and divide their ſum by ſix, or the number of trials; the quotient will be the mean of all the trials. This reſult is to be placed in a column of a table, next to that which contains the number of the magnifiers.

By the aſſiſtance of the ſectoral ſcale, we obtain with eaſe a ſmall part of an inch. This ſcale is ſhewn at Fig. 5, 6, 7, Plate II. A, in which, the two lines c a c b, with the ſide a b, form an iſoſceles triangle; each of the ſides is two inches long, and the baſe one-tenth of an inch. The longer ſides may be of any given length, and the baſe ſtill only of one-tenth of an inch. The longer lines may be conſidered as the line of lines upon a ſector opened to one-tenth of an inch. Hence, whatever number of equal parts c a c b are divided into, their tranſverſe meaſure will be ſuch a part of one-tenth, as is expreſſed by their diviſions. Thus, if it be divided into ten equal parts, this will divide the inch into one hundred equal parts; the firſt diviſion next c will be equal to one hundredth part of an inch, becauſe it is the tenth part of one-tenth of an inch. If theſe lines are divided into twenty equal parts, the inch will be by that means divided into two hundred equal parts. Laſtly, if ab ca are made three inches long, and divided into one hundred equal parts, we obtain with eaſe the one thouſandth part. The ſcale is repreſented as ſolid at Fig. 6, but as perforated at Fig. 5 and 7; ſo that the light paſſes through the aperture, when the ſectoral part is placed on the ſtage.

To uſe this ſcale, firſt, fix the micrometer, Fig. 8, Plate II. A, to the body of the microſcope; then fit the ſectoral ſcale, Fig. 7, in the ſtage, and adjuſt the microſcope to it's proper focus or diſtance from the ſcale, which is to be moved till the baſe appears in the middle of the field of view; then bring the needle point g, Fig. 8, (by turning the ſcrew L) to touch one of the lines c a exactly at the point anſwering to 20 on the ſectoral ſcale. The index a of the micrometer, Fig. 8, is to be ſet to the firſt diviſion, and that on the dial plate to 20, which is both the beginning and end of it's diviſions: we are then prepared to find the magnifying power of every magnifier in the compound microſcope which we are uſing.

Example; every thing being prepared agreeable to the foregoing directions, ſuppoſe you are deſirous of aſcertaining the magnifying power of the lens marked No. 4; turn the micrometer ſcrew, until the point of the needle has paſſed over the magnified image of the tenth part of one inch ; then the diviſion, where the two indices remain, will ſhew how many revolutions, and parts of a revolution, the ſcrew has made, while the needle point traverſed the magnified image of the one-tenth of an inch ; ſuppoſe the reſult to be twenty-ſix revolutions of the ſcrew, and fourteen parts of another revolution, this is equal to 26 multiplied by 20, added to 14 ; that is, 534 thouſandth parts of an inch.

The twenty-ſix diviſions found on the ſtrait ſcale of the micrometer, while the point of the needle paſſed over the magnified image of one-tenth part of an inch, were multiplied by 20, becauſe the circular plate C D, Fig. 8, is divided into 20 equal parts; this produced 520 ; then adding the fourteen parts of the next revolution, we obtain the 534 thouſandth parts of an inch, or 5 tenths and 34 hundredth parts of another tenth, which is the meaſure of the magnified image of one-tenth of an inch, at the aperture of the eye glaſſes, or at their foci. Now if we ſuppoſe the focus of the two eye glaſſes to be one inch, the double thereof is two inches ; or if we reckon in the thouſandth part of an inch, we have two thouſand parts for the diſtance of the eye from the needle point of the micrometer. Again, if we take the diſtance of the image from the object at the ſtage at ſix inches, or ſix thouſandths, and add thereto two thouſand, double the diſtance of the focus of the eye glaſs, we ſhall have eight thouſand parts of an inch for the diſtance of the eye from the object ; and as from the propoſition, page 55, we gather that the glaſſes double the image, we muſt double the number 534 found upon the micrometer, which then makes 1068 : then, by the following analogy, we ſhall obtain the number of times the microſcope magnifies the diameter of the object; ſay, as 240, the diſtance of the eye from the image of the object, is to 800, the diſtance of the eye from the object, ſo is 1068, double the meaſure found on the micrometer, to 3563, or the number of times the microſcope magnifies the diameter of the object. By working in this manner, the magnifying power of each lens uſed with the compound microſcope, may be eaſily found, though the reſult will be different in different compound microſcopes, varying according to the combination of the lenſes, their diſtance from the object and one another, &c.

Having diſcovered the magnifying power of the microſcope, with the different object lenſes that are uſed therewith, our next ſubject is to find out the real ſize of the objects themſelves, and their different parts; this is eaſily effected, by finding how many revolutions of the micrometer-ſcrew anſwer to a known meaſure on the ſectoral ſcale, or other object placed on the ſtage; from the number thus found, a table ſhould be conſtructed, expreſſing the value of the different revolutions of the micrometer with that object lens, by which the primary number was obtained. Similar tables muſt be conſtructed for each object lens. By a ſet of tables of this kind, the obſerver may readily find the meaſure of any object he is examining; for he has only to make the needle point traverſe over this object, and obſerve the number of revolutions the ſcrew has made in it's paſſage, and then look into his table for the real meaſure which correſponds to this number of revolutions, which is the meaſure required.

# CHAP. III.

## A DESCRIPTION OF THE MOST APPROVED MICROSCOPES, AND THE METHOD OF USING THEM.

IN the preceding chapter I have endeavoured to give a comprehenſive view of the theory of the microſcope, and the principles on which the wonderful effects of this inſtrument depend. I ſhall now proceed to deſcribe the various inſtruments themſelves, their apparatus, and the moſt eaſy and ready mode of applying them to uſe; ſelecting for deſcription thoſe, that from ſome peculiar advantage in their conſtruction, or from the reputation of the authors who have recommended and uſed them, are in moſt general uſe. What is ſaid of theſe will, I hope, be ſufficient to enable the reader to manage any other kind that may fall in his way.

### DESCRIPTION OF ADAMS'S IMPROVED AND UNIVERSAL LUCERNAL MICROSCOPE, Fig. 1, Plate III.

This microſcope was originally thought of, and in part executed by my father; I have, however, ſo improved and altered it, both in conſtruction and form, as to render it altogether a different inſtrument. The approbation it has received from the moſt experienced microſcopic obſervers, as well as the great demand I have had for them, has fully repaid my pains and expences, in bringing it to it's preſent ſtate of perfection.

As the far greater part of the objects which ſurround us are opake, and very few are ſufficiently tranſparent to be examined by the common microſcopes, an inſtrument that could be readily applied to the examination of opake objects, has always been a deſideratum. Even in the examination of tranſparent objects, many of the fine and more curious portions are loſt, and drowned as it were in the light which muſt be tranſmitted through them; while different parts of the ſame object appear only as dark lines or ſpots, becauſe they are ſo opake, as not to permit any light to paſs through them. Theſe difficulties, as well as many more, are obviated in the lucernal microſcope; by which, opake objects, of various ſizes, may be ſeen with eaſe and diſtinctneſs; the beautiful colours with which moſt of them are adorned, are rendered more brilliant, without changing in the leaſt the real tint of the colour. The concave and convex parts of an object retain alſo their proper form.

The facility with which all opake objects are applied to this inſtrument, is another conſiderable advantage, and almoſt peculiar to itſelf; as the texture and configuration of the more tender parts are often hurt by previous preparation, every object may be examined by this inſtrument, firſt, as opake, and afterwards, if the texture will admit of it, as tranſparent.

The lucernal microſcope does not in the leaſt fatigue the eye; the object appears like nature itſelf, giving eaſe to the ſight, and pleaſure to the mind: there is alſo, in the uſe of this inſtrument, no occaſion to ſhut that eye which is not directed to the object.

A further advantage peculiar to this microſcope is, that by it the outlines of every object may be taken, even by thoſe who are not accuſtomed to draw; while thoſe who can draw well, will receive great aſſiſtance, and execute their work with more accuracy, and in leſs time than they would otherwiſe have been able to have performed it in. Moſt of the deſigns for this work were taken with the lucernal microſcope; and, I hope, the accuracy with which they are executed, will be deemed a ſufficient teſtimony in favour of the inſtrument. In this point of view, it will, I think, be found of great uſe to the anatomiſt, the botaniſt, the entomologiſt, &c. as it will enable them not only to inveſtigate the object of their reſearches, but to convey to others accurate delineations of the ſubject they wiſh to deſcribe.

By the addition of a tin lanthorn to this apparatus, tranſparent objects may be thrown on a ſcreen, and exhibited at one view to a large company, as by the ſolar microſcope.

Tranſparent objects may be examined with this inſtrument in three or four different modes; from a blaze of light almoſt too great for the eye to bear, to that which is perfectly eaſy to it.

When this inſtrument is fitted up in the beſt way, we generally ſend a ſmall double and ſingle microſcope with it.

Fig. 1, Plate I. repreſents the IMPROVED LUCERNAL MICROSCOPE, mounted to view opake objects; A B C D E is a large

mahogany

mahogany pyramidical box, which forms the body of the microſcope; it is ſupported firmly on the braſs pillar F G, by means of the ſocket H, and the curved piece I K.

L M N is a guide for the eye, in order to direct it in the axis of the lenſes; it conſiſts of two braſs tubes, one ſliding within the other, and a vertical flat piece, at the top of which is the hole for the eye. The outer tube is ſeen at M N, the vertical piece is repreſented at L M. The inner tube may be pulled out, or puſhed in, to adjuſt it to the focus of the glaſſes. The vertical piece may be raiſed or depreſſed, that the hole, through which the object is to be viewed, may coincide with the center of the field of view; it is fixed by a milled ſcrew at M, which could not be ſhewn in this figure.

At N is a dove-tailed piece of braſs, made to receive the dove-tail at the end of the tubes M N, by which it is affixed to the wooden box A B C D E. The tubes M N may be removed from this box occaſionally, for the convenience of packing it up in a leſs compaſs.

O P a ſmall tube which carries the magnifiers.

O one of the magnifiers; it is ſcrewed into the end of a tube, which ſlides within the tube P; the tube P may be unſcrewed occaſionally from the wooden body.

Q R S T V X a long ſquare bar, which paſſes through the ſockets Y Z, and carries the ſtage or frame that holds the objects; this bar may be moved backward or forward, in order to adjuſt it to the focus, by means of the pinion which is at a.

b e is a handle furniſhed with an univerſal joint, for more conveniently turning the pinion. When the handle is removed, the nut, Fig. 2, may be uſed in it's ſtead.

d e is a braſs bar, to ſupport the curved piece K I, and keep the body A B firm and ſteady.

f g h i is the ſtage for opake objects; it fits upon the bar Q R S T by means of the ſocket h i, and is brought nearer to, or removed further from, the magnifying lens, by turning the pinion a: the objects are placed in the front ſide of the ſtage, (which cannot be ſeen in this figure) between four ſmall braſs plates; the edges of two of theſe are ſeen at k l. The two upper pieces of braſs are moveable; they are fixed to a plate, which is acted on by a ſpiral ſpring, that preſſes them down, and confines the ſlider with the objects; this plate, and the two upper pieces of braſs, are lifted up by the ſmall nut m.

At the lower part of the ſtage, there is a ſemicircular lump of glaſs n, which is deſigned to receive the light from the lamp, Fig. 3, and to collect and throw it on the concave mirror O, from whence it is to be reflected on the object.

The upper part, f g r s, of the opake ſtage takes out, that the ſtage for tranſparent objects may be inſerted in it's place.

Fig. 4, repreſents the ſtage for tranſparent objects; the two legs, 5 and 6, fit into the top of the under part r s h i of the ſtage for opake objects; 7 is the part which confines or holds the ſliders, and through which they are to be moved; 9 and 10 a braſs tube, which contains the lenſes for condenſing the light, and throwing it upon the object; there is a ſecond tube within that, marked 9 and 10, which may be placed at different diſtances from the object by the pin 11.

When this ſtage is uſed as a ſingle microſcope, without any reference to the lucernal, the magnifiers, or object lenſes, are to be ſcrewed into the hole 12, and to be adjuſted to a proper focus by the nut 13.

N. B. At the end A B of the wooden body, there is a ſlider, which is repreſented as partly drawn out at A; when quite taken out, three grooves will be perceived, one of which contains a board that forms the end of the box, the next contains a frame with a greyed glaſs, the third, or that fartheſt from the end A B, two large convex lenſes.

## OF THE LAMP.

Fig. 3, repreſents one of ARGAND's lamps, which are the moſt ſuitable for microſcopic purpoſes, on account of the clearneſs, the intenſity, and the ſteadineſs of the light. The following account of the method of managing them, with other obſervations, is copied from an account given by Mr. Parker with thoſe he ſells.

The principle on which the lamp acts, conſiſts in diſpoſing the wick in thin parts, ſo that the air may come into contact with all the burning fuel, by which means, together with an increaſe of the current of air occaſioned by rarefaction in the glaſs tube, the whole of the fuel is converted into flame.

The wicks are circular, and, the more readily to regulate the quantity of light, are fixed on a braſs collar with a wire handle, by means of which they are raiſed or depreſſed at pleaſure.

To fix the wick on, a wood mandril is contrived, which is tapered at one end, and has a groove turned at the other.

The wick has a ſelvage at one end, which is to be put foremoſt on the mandril, and moved up to the groove; then putting the groove into the collar of the wick-holder, the wick is eaſily puſhed forward upon it.

The wick-holder and wick being put quite down in their place, the ſpare part of the wick ſhould, while dry, be ſet alight, and ſuffered to burn to the edge of the tubes; this will leave it more even than by cutting, and, being black by burning, will be much eaſier lighted: for this reaſon, the black ſhould never be quite cut off.

The lamp ſhould be filled an hour or two before it is wanted, that the cotton may imbibe the oil and draw the better.

The lamps which have a reſervoir and valve, need no other direction for filling than to do it with a proper trimming pot, carefully obſerving when they are full; then pulling up the valve by the point, the reſervoir, being turned with the other hand, may be replaced without ſpilling a drop.

Thoſe lamps which fill in the front like a bird-fountain, muſt be reclined on the back to fill, and this ſhould be done gently, that the oil in the burner may return into the body when ſo placed and filled; if, by being too full, any oil appears above the guard, only move the lamp a little, and the oil will diſappear; the lamp may then be placed erect, and the oil will flow to it's proper level.

The oil muſt be of the ſpermaceti kind, commonly called chamber oil, which may generally be diſtinguiſhed by it's paleneſs, tranſparency, and inoffenſive ſcent; all thoſe oils which are of a red and brown colour, and of an offenſive ſcent, ſhould be carefully avoided, as their glutinous parts clog the lamp, and the impurities in ſuch oil not being inflammable, will accumulate and remain in the form of a cruſt on the wick. Seal oil is nearly as pale and ſweet as chamber oil; but being of a heavy ſluggiſh quality, is not proper for lamps with fine wicks.

Whenever bad oil has been uſed, on changing it, the wick muſt alſo be changed, becauſe after having imbibed the coarſe particles in it's capillary tubes, it will not draw up the fine oil.

To obtain the greateſt degree of light, the wick ſhould be trimmed exactly even, the flame will then be completely equal.

There will be a great advantage in keeping the lamp clean, eſpecially the burner and air tubes; the neglect of cleanlineſs in lamps is too common: a candleſtick is generally cleaned every time it is uſed, ſo ſhould a lamp; and if a candleſtick is not to be objected to becauſe it does not give light after the candle is exhauſted, ſo a lamp ſhould not be thought ill of, if it does not give light when it wants oil or cotton; but this laſt has often happened, becauſe the deficiency is leſs viſible.

The glaſs tubes are beſt cleaned with a piece of waſh leather.

If a fountain-lamp is left partly filled with oil, it may be liable to overflow; this happens by the contraction of the air when cold, and it's expanſion by the warmth of a room, the rays of the ſun, or the heat of the lamp when re-lighted: this accident may be effectually prevented by keeping the reſervoir filled, the oil not being ſubject to expanſion like air. On this account, thoſe with a common reſervoir are beſt adapted for microſcopic purpoſes.

## TO EXAMINE OPAKE OBJECTS WITH THE LUCERNAL MICROSCOPE.

The microſcope is repreſented as mounted, and entirely ready for this purpoſe, in Fig. 1, Plate III.

To render the uſe of this inſtrument eaſy, it is uſually packed with as many of the parts together as poſſible; it occupies on this account rather more room, but is much leſs embarraſſing to the obſerver, who has only three parts to put on after it is taken out of it's box, namely, the guide for the eye, the ſtage, and the tube with it's magnifier.

But to be more particular, take out the wooden ſlide A, then lift out the cover and the grey glaſs from their reſpective grooves under the ſlide A.

Put the end N of the guide for the eye L M N into it's place, ſo that it may ſtand in the poſition which is repreſented in this figure.

Place the ſocket, which is at the bottom of the opake ſtage, on the bar Q X T, ſo that the concave mirror o may be next the end D E of the wooden body.

Screw the tubes P O into the end D E. The magnifier you intend to uſe is to be ſcrewed on the end o of theſe tubes.

The handle G b, or milled nut, Fig. 2, muſt be placed on the ſquare end of the pinion a.

Place the lamp lighted before the glaſs lump n, and the object you intend to examine between the ſpring plates of the ſtage, and the inſtrument is ready for uſe.

In all microſcopes, there are two circumſtances which muſt be particularly attended to; the modification of the light, or the proper quantity to illuminate the object; ſecondly, the adjuſtment of the inſtrument to the focus of the glaſſes and the eye of the obſerver. In the uſe of the lucernal microſcope there is a third circumſtance, which is, the regulation of the guide for the eye, each of which I ſhall conſider by itſelf.

1. To throw the light upon the object. The flame of the lamp is to be placed rather below the center of the glaſs lump n, and as near it as poſſible; the concave mirror o muſt be ſo inclined and turned, as to receive the light from the glaſs lump, and reflect it thence upon the object; the beſt ſituation of the concave mirror,

and the flame of the lamp, depends on a combination of circumſtances, which a little practice will diſcover.

2. To regulate the guide for the eye, or to place the center of the eye-piece L, ſo that it may coincide with the focal point of the lenſes, and the axis of viſion. Lengthen and ſhorten the tubes M N by drawing out or puſhing in the inner tube, and raiſing or depreſſing the eye-piece M L, till you find the large lens (which is placed at the end A B of the wooden body) filled by an uniform field of light, without any priſmatic colours round the edge; for till this piece is properly fixed, the circle of light will be very ſmall, and only occupy a part of the lens: the eye muſt be kept at the center of the eye-piece L, during the whole of the operation; which may be rendered ſomewhat eaſier to the obſerver, on the firſt uſe of the inſtrument, if he holds a piece of white paper parallel to the large lens, removing it from, or bringing it nearer to them, till he finds the place, where a lucid circle, which he will perceive on the paper, is brighteſt and moſt diſtinct, then to fix the center of the eye-piece to coincide with that ſpot; after which a very ſmall adjuſtment will ſet it perfectly right.

3. To adjuſt the lenſes to their focal diſtance. This is effected by turning the pinion a, the eye being at the ſame time at the eye-piece L. I often place the grey glaſs before the large lenſes, while I am regulating the guide for the eye, and adjuſting for the focal diſtance.

If the obſerver, in the proceſs of his examination of an object, advances rapidly from a ſhallow to a deep magnifier, he will ſave himſelf ſome labour by pulling out the internal tube at O.

The upper part f g r s of the ſtage, is to be raiſed or lowered occaſionally, in order to make the center of the object coincide with the center of the lens at O.

To delineate objects, the grey glaſs muſt be placed before the large lenſes; the picture of the object will be formed on this glaſs, and the outline may be accurately taken, by going over the picture with a pencil.

The opake part may be uſed in the day-time without a lamp, provided the large lenſes at A B are ſcreened from the light.

## TO USE THE LUCERNAL MICROSCOPE IN THE EXAMINATION OF TRANSPARENT OBJECTS.

The microſcope is to remain as before: the upper part f g s of the opake ſtage muſt be removed, and the ſtage for tranſparent objects, repreſented at Fig. 4, put in it's place; the end, Fig. 9 and 10, to be next the lamp.

Place the greyed glaſs in it's groove at the end A B, and the objects in the ſlider-holder at the front of the ſtage; then tranſmit as ſtrong a light as you are able on the object, which you will eaſily do by raiſing or lowering the lamp.

The object will be beautifully depicted on the grey glaſs: it muſt be regulated to the focus of the magnifier, by turning the pinion a.

The object may be viewed either with or without the guide for the eye; a ſingle obſerver will ſee an object to the greateſt advantage by uſing this guide, which is to be adjuſted as we have deſcribed, page 75. If two or three wiſh to examine the object at the ſame time, the guide for the eye muſt be laid aſide.

Take the large lens out of the groove, and receive the image on the grey glaſs; in this caſe, the guide for the eye is of no uſe: if the grey glaſs is taken away, the image of the object may be received on a paper ſcreen.

Take out the grey glaſs, replace the large lenſes, and uſe the guide for the eye; attend to the foregoing directions, and adjuſt the object to it's proper focus. You will then ſee the object in a blaze of light almoſt too great for the eye, a circumſtance that will be found very uſeful in the examination of particular objects; the edges of the object in this mode will be ſomewhat coloured, but as it is only uſed in this full light for occaſional purpoſes, it has been thought better to leave this ſmall imperfection, than by remedying it, to ſacrifice greater advantages; the more ſo, as this ſault is eaſily corrected, and a new and intereſting view of the object is obtained, by turning the inſtrument out of the direct rays of light, and permitting them to paſs through only in an oblique direction, by which the upper ſurface is in ſome degree illuminated, and the object is ſeen partly as opake, partly as tranſparent. It has been already obſerved, that the tranſparent objects might be placed between the ſlider-holders of the ſtage for opake objects, and then be examined as if opake.

Some tranſparent objects appear to the greateſt advantage when the lens at 9 and 10 is taken away; as, by giving too great a quantity of light, it renders the edges leſs ſharp.

The variety of views which may be taken of every object, by means of the improved lucernal microſcope, will be found to be of great uſe to an accurate obſerver: it will give him an opportunity of correcting or confirming his diſcoveries, and inveſtigating thoſe parts in one mode, which are inviſible in another.

## TO THROW THE IMAGE OF TRANSPARENT OBJECTS ON A SCREEN, AS IN THE SOLAR MICROSCOPE.

It has been long a microſcopical deſideratum, to have an inſtrument by which the image of tranſparent objects might be thrown on a ſcreen, as in the common ſolar microſcope; and this not only becauſe the ſun is ſo uncertain in this climate, and the uſe of the ſolar microſcope requires confinement in the fineſt part of the day, when time ſeldom hangs heavy on the mind, but as it alſo affords an increaſe of pleaſure, by diſplaying it's wonders to ſeveral perſons at the ſame inſtant, without the leaſt fatigue to the eye.

This purpoſe is now effectually anſwered, by affixing the tranſparent ſtage of the lucernal to a lanthorn, with one of Argand's lamps.—The lamp is placed within the lanthorn, and the end 9, 10 of the tranſparent ſtage is ſcrewed into a female ſcrew, which is rivetted in the ſliding part of the front of the lanthorn; the magnifying lenſes are to be ſcrewed into the hole repreſented at 12; they are adjuſted by turning the milled nut. The quantity of light is to be regulated, by raiſing and lowering the ſliding-plate, or the lamp. N. B. This part, with it's lanthorn and lamp, may be had ſeparate from the lucernal microſcope.

## APPARATUS WHICH USUALLY ACCOMPANIES THE IMPROVED LUCERNAL MICROSCOPE.

The ſtage for opake objects, with it's ſemicircular lump of glaſs, and concave mirror.

The ſtage for tranſparent objects, which ſits on the upper part of the foregoing ſtage.

The ſliding tube, to which the magnifiers are to be affixed; one end of theſe is to be ſcrewed on the end B of the wooden body; the magnifier in uſe is to be ſcrewed to the other end of the inner tube.

Eight magnifying lenſes; theſe are ſo conſtructed, that they may be combined together, and thus produce a very great variety of magnifying powers.

A fiſh-pan, ſuch as is repreſented at I, Plate IX.

A ſteel wire L, with a pair of nippers at one end.

A ſmall cylinder of ivory l at the other.

A ſlider of braſs N, containing a flat glaſs ſlider, and a braſs ſlider, into which are fitted ſome ſmall concave glaſſes.

A pair of forceps.

Six large ivory ſliders, with tranſparent objects, and ſix ſmall ditto with ditto.

Fourteen wooden ſliders, with four opake objects in each ſlider, and two ſpare ſliders.

Some capillary tubes, for viewing ſmall animalcula.

The uſe and manner of uſing the articles of the apparatus will be more particularly explained when we deſcribe the figures which are delineated in Plate IX.

### DESCRIPTION OF CUFF'S DOUBLE-CONSTRUCTED MICROSCOPE, REPRESENTED AT Fig. 1, Plate VII. A.

This inſtrument was firſt deſcribed by Mr. Baker, and recommended by him. It was alſo deſcribed by my father in the fourth edition of his Micrographia Illuſtrata, page xix.

A B C repreſents the body of this microſcope; it contains an eye-glaſs at A, a broad lens at B, and a magnifier which is ſcrewed on at C.

The body of the microſcope is ſupported by the arm D E, from which it may be removed at pleaſure.

The arm D E is fixed on the ſliding bar F, and may be raiſed or depreſſed to any height within it's limits.

The main pillar a b is fixed in the box b e, and by means of the braſs foot d is ſcrewed to the mahogany pedeſtal x Y, in which is a drawer containing all the apparatus.

O, a milled-headed ſcrew, to tighten the bar F when the adjuſting ſcrew c g is uſed.

p q is the ſtage, or plate, which carries the objects; it has a hole at the center n.

G a concave mirror, that may be turned in any direction, to reflect the light of the candle, or the ſky, upon the object.

## TO USE THIS MICROSCOPE.

Screw the magnifier you intend to uſe to the end c of the body, place the ſlider-holder P in the hole n, and the ſlider with the object between the plates of the ſlider-holder; ſet the upper edge of the bar D E to coincide with the diviſions which correſpond to the magnifier you have in uſe, and pinch the milled nut; now reflect a proper quantity of light upon the object, by means of the concave mirror G, and regulate the body exactly to the eye and the focus of the glaſſes, by the adjuſting ſcrew c g.

To view opake objects, take away the ſlider-holder P, and place the object on a flat glaſs under the center of the body, or on one end of the jointed nippers o. Then ſcrew the ſilver concave ſpeculum to the end of the cylinder L, and ſlide this cylinder on the lower part of the body, ſo that the upper edge thereof may coincide with the line which has the ſame mark with the magnifier that is then uſed; reflect the light from the concave mirror G to the ſilver ſpeculum, from which it will again be reflected on the object. The glaſſes are to be adjuſted to their focal diſtance as before directed.

## A LIST OF THE APPARATUS OF CUFF'S DOUBLE-CONSTRUCTED MICROSCOPE.

H a convex lens, to collect the rays of light from the ſun or a candle, and condenſe them on the object.

L a cylindrical tube, open at each ſide, with a concave ſpeculum ſcrewed to the lower end h.

P the ſlider-holder; it conſiſts of a cylindrical tube, in which an inner tube is forced upwards by a ſpiral ſpring, it is uſed to receive an ivory ſlider K, which is to be ſlid between the plates h and i. The cylinder P fits the hole n in the ſtage: the hollow part at k is deſigned to receive a glaſs tube N.

R is a braſs cone, to be put under the bottom of the cylinder P, to intercept occaſionally ſome of the rays of light.

S a box containing a concave and a flat glaſs, between which a ſmall living inſect may be confined; it is to be placed over the hole n.

T a flat glaſs, to lay any occaſional object upon; there is alſo a concave one for fluids.

O a long ſteel wire, with a ſmall pair of pliers at one end, and a point at the other, deſigned to ſtick or hold objects; it ſlips backwards and forwards in the ſhort tube o; the pin p fits into the hole of the ſtage.

W a little round ivory box, to hold a ſupply of talc and rings for the ſliders.

Z a hair bruſh, to wipe any duſt off the glaſſes, or to take up by the other end a drop of any liquid.

V a ſmall ivory cylinder, that fits on the pointed end of the ſteel wire O; it is deſigned for opake objects. Light-coloured ones are to be ſtuck upon the dark ſide, and vice verſa.

Y a common magnifying glaſs, for any occaſional purpoſe.

M a fiſh-pan, whereon to faſten a ſmall fiſh, to view the circulation of the blood: the tail is to be ſpread acroſs the oblong hole at the ſmall end, and tied faſt, by means of a ribband fixed thereto; the knob l is to be ſhoved through the ſlit made in the ſtage, that the tail may be brought under the magnifier.

## THE DESCRIPTION AND USE OF ADAMS'S IMPROVED DOUBLE AND SINGLE MICROSCOPE, REPRESENTED Fig. 1, Plate IV.

It is the compound microſcope, which is at preſent in moſt general uſe. The improvements, though few in number, are eſſential to the uſe thereof. The field of view is conſiderably larger than in the former microſcope. The ſtage and the mirrors are both moveable, ſo that their reſpective diſtances may be eaſily varied. There is alſo a condenſing glaſs to the ſtage, for increaſing the denſity of the light, when it is reflected by the mirror from a candle or lamp. It is furniſhed with two mirrors, one plane, and the other concave, and may be uſed as a ſingle microſcope.

A B, Fig. 1, Plate IV. repreſents the body of the microſcope, containing a double eye glaſs, and a body glaſs; it is here ſhewn as ſcrewed to the arm C D, from whence it may be occaſionally removed, either for the convenience of packing, or when the inſtrument is to be uſed as a ſingle microſcope.

The eye glaſſes and the body glaſſes are contained in a tube which fits into the exterior tube A B; by pulling out a little this tube, when the microſcope is in uſe, the magnifying power of each lens is increaſed.

The body A B of the microſcope is ſupported by the arm C D, this arm is fixed to the main pillar C F, which is ſcrewed firmly to the mahogany pedeſtal G H; there is a drawer to this pedeſtal, which holds the apparatus.

N I S is the plate or ſtage which carries the ſlider-holder K L, this ſtage is moved up or down the pillar C F, by turning the milled nut M; this nut is fixed to a pinion, that works in a toothed rack cut on one ſide of the pillar. By means of this pinion, the ſtage may be gradually raiſed or depreſſed, and the object adjuſted to the focus of the different lenſes.

K L is the ſlider-holder, which fits into a hole that is in the middle of the ſtage N I S; it is uſed to confine and guide either the motion of the ſliders which contain the objects, or the glaſs tubes that are deſigned to confine ſmall fiſhes, for viewing the circulation of the blood. The ſliders are to be paſſed between the two upper plates, the tubes through the bent plates.

L is a braſs tube, to the upper part of which is fixed the condenſing lens before ſpoken of; it fits into the under part of the ſlider-holder N I, and may be ſet at different diſtances from the object, according to it's diſtance from the mirror or the candle. This tube is ſeen further drawn out in Fig. 2, Plate IV.

O is the frame which holds the two reflecting mirrors, one of which is plane, the other concave. Theſe mirrors may be moved in various directions, in order to reflect the light properly, by means of the pivots on which they move, in the ſemicircle Q S R, and the motion of the ſemicircle itſelf on the pin S; the concave mirror generally anſwers beſt in the day-time; the plane mirror combines better with the condenſing lens, and a lamp or candle. At D there is a ſocket for receiving the pin of the arm Q, Plate IX. to which the concave ſpeculum, for reflecting light on opake objects, is fixed.

At S is a hole and ſlit for receiving either the nippers L, Plate IX. or the fiſh-pan I; when theſe are uſed, the ſlider-holder muſt be removed.

T, a hole to receive the pin of the convex lens M, Plate IX.

## TO USE THE IMPROVED DOUBLE MICROSCOPE.

Take the microſcope out of the box. Screw the body into the round end of the upper part of the arm C D.

Place the braſs ſliders, which contain the magnifiers, into the dove-tailed ſlit which is on the under ſide of the aforeſaid arm, as ſeen at E, Fig. 1, Plate IV. and ſlide it forwards, until the magnifier you mean to uſe is under the center of the body: oppoſite to each magnifier in this ſlide there is a notch, and in the dove-tailed part of the arm C D there is a ſpring, which falls into the above-mentioned notch, and thus makes each magnifier coincide with the center of the body.

Paſs the ivory ſlider you intend to uſe between the upper plates of the ſlider-holder K L, and then reflect as ſtrong a light as you can on the object, by means of one of the mirrors; after this, adjuſt the object to the focus of the magnifier and your eye, by turning the milled ſcrew M; the motion of this raiſes and depreſſes the ſtage N I S. The degree of light neceſſary for each object, and the accuracy required in the adjuſtment of the lens to their proper focal diſtance from the object, will be eaſily attained by a little practice.

When opake objects are to be examined, remove the ſlider-holder, and place the object on a flat glaſs, or fix it to the nippers L, Plate IX. the pin of theſe fit into the hole on the ſtage; ſcrew the concave ſpeculum R, Plate IX. into the arm Q, Plate

IX. and then paſs the pin of this arm through the ſocket D, Fig. 1, Pl. IV. the light is now to be reflected from the concave mirror to the ſilver ſpeculum, and from this down on the object. No exact rule can be given for reflecting the light on the object; we muſt therefore refer the reader to the mother of all aptneſs, practice. The ſpeculum muſt be moved lower or higher, to ſuit the focus of the different magnifiers, and the nature of the object.

The preceding directions apply equally to the uſing of this inſtrument as A SINGLE MICROSCOPE, with this difference only, that the body A B is then removed, and the eye is applied to the upper ſurface of the arm C D, exactly over the magnifiers.

## A LIST OF THE APPARATUS OF THE IMPROVED COMPOUND MICROSCOPE.

The ſlider, with the magnifiers.

The body of the microſcope.

The ſlider-holder.

The tube, with the condenſing lens.

The pin and arm for the ſilver ſpeculum.

The ſilver ſpeculum.

A braſs box for the ſilver ſpeculum.

A braſs cone to place under the ſlider-holder.

The jointed nippers.

A cylinder of ivory, to fix on the pointed end of the nippers.

Six ivory ſliders, five of which are filled with objects.

A magnifier for the hand.

A fiſh pan.

A round braſs box, with glaſs ends, for confining living objects.

An ivory box, to hold ſpare rings and talc for the ſliders.

A round flat glaſs, fitted to the hole in the ſtage.

A concave ditto.

A ſlider of braſs, containing a flat glaſs ſlider, and a braſs ſlider, into which are fitted ſmall concave glaſſes.

Some glaſs tubes.

A ſmall pair of forceps.

A ſlip or two of flat glaſs.

A ſmall bruſh, or hair pencil.

The uſe of each article of the apparatus, and the method of applying it to uſe, will be deſcribed in the latter end of this chapter.

## OF THE IMPROVED COMPOUND MICROSCOPE, REPRESENTED AT Fig. 2, Plate IV.

The advantages of this over the preceding compound microſcope, conſiſts, firſt, in the motion which may be given to the body, the ſtage, and the mirrors, by means of the joint c d, which has both a vertical and horizontal motion; ſo that the microſcope may be placed either in an horizontal or inclined ſituation, and thus be adapted to the eaſe of the obſerver, and be uſed when he is ſitting down. If the mirror Q O R is taken off, the light will be conveyed in a direct line to the object, without any reflection. Secondly, that the body may be moved over any part of the ſtage, and thus over the object. The arm which carries the body, moves to the right or left on a central pin, and may alſo be moved backwards or forwards by the milled nut b. Thirdly, the concave and flat mirrors are much larger than thoſe of Fig. 1. In every other reſpect, the microſcope is ſimilar to the foregoing, and may be managed by the deſcription thereof; for which purpoſe, ſimilar letters are affixed to the ſame parts.

## A DESCRIPTION OF CULPEPER'S, OR THE THREE-PILLARED MICROSCOPE, Fig. 3, Plate IV.

This inſtrument is recommended by it's ſimplicity and cheapneſs; it is eaſily managed, and gives a pleaſing view of an object. It is true, it is precluded by it's form from ſome of the advantages of the two foregoing inſtruments, becauſe both the ſtage and the mirror are confined.

This microſcope conſiſts of a large exterior body A B C D, ſupported on three ſmall ſcroles, which are fixed to the ſtage E F; the ſtage is ſupported by three larger ſcroles, that are ſcrewed to the mahogany pedeſtal G H. There is a drawer in the pedeſtal which holds the apparatus. The concave mirror is fitted to a ſocket in the center of the pedeſtal. The lower part L M C D of the body forms an exterior tube, into which the upper part of the body A B L M ſlides, and may be moved up or down, ſo as to bring the magnifiers, which are ſcrewed on at N, nearer to, or further from the object.

### To use Culpeper's Microscope.

Screw one of the buttons which contains a magnifying lens, to the end N of the body; place the ſlider, with the objects, between the plates of the ſlider-holder. Then, to attain diſtinct viſion, and a pleaſing view of the object, adjuſt the body to the focus of the lens you are uſing, by moving the upper part gently up and down, and regulate the light by the concave mirror.

For opake objects, two additional pieces muſt be uſed; the firſt is, a cylindrical tube of braſs, repreſented at X, Plate IX. which fits on the cylindrical part at N of the body; the ſecond piece is the concave ſpeculum H, Plate IX. this is to be ſcrewed to the lower end of the aforeſaid tube: the upper edge of this tube ſhould be made to coincide with the line, which has the ſame number affixed to it, as to the magnifier you are uſing; ex. gr. if you are making uſe of the magnifier marked 5, ſlide the tube to the circular line on the tube N, that is marked alſo with No. 5.

The ſlider-holder ſhould be removed when you are going to view opake objects, and a plane glaſs ſhould be placed on the ſtage in it's ſtead to receive the object; or it may be placed in the nippers L, Plate IX. the pin of which fits into the hole in the ſtage.

## A LIST OF THE APPARATUS TO CULPEPER'S MICROSCOPE.

Five magnifiers, each fitted in a braſs button; one of theſe is ſeen at B, Plate IX.

Six ivory ſliders, five of them with objects.

A braſs tube X, Plate IX. to hold the concave ſpeculum.

The concave ſpeculum in a braſs box.

A fiſh-pan.

A ſet of glaſs tubes.

A flat glaſs fitted to the ſtage.

A concave glaſs fitted to the ſtage.

A pair of forceps.

A ſteel wire, with a pair of nippers at one end, and a point at the other.

A ſmall ivory cylinder, to fit on the pointed end of the aforeſaid nippers.

A convex lens, moveable in a braſs ſemicircle; this is affixed to a long braſs pin, which fits into a hole on the ſtage.

If the reader wants a more particular deſcription of any of the articles of this apparatus, he will find it at the latter end of this chapter.

## A DESCRIPTION OF THE IMPROVED SOLAR MICROSCOPE, WHICH IS CONSTRUCTED TO EXHIBIT TRANSPARENT AND OPAKE OBJECTS, Fig. 1, Plate V.

The ſolar microſcope is generally ſuppoſed to afford the moſt entertainment, on account of the wonderful extent of it's magnifying power, and the eaſe with which ſeveral perſons may view each ſingle object at the ſame time. The uſe of it was, however, confined for many years only to tranſparent objects. About the year 1774, Mr. B. Martin ſo far improved this inſtrument, as to render it applicable to opake, as well as to tranſparent objects, exhibiting the magnified image of either kind on a large ſcreen. Speaking of it himſelf, he ſays, "With this inſtrument all opake objects, whether of the animal, vegetable, or mineral kingdom, may be exhibited in great perfection, in all their native beauty;

the lights and ſhades, the prominencies and cavities, and all the varieties of different hues, tints, and colours, heightened by the reflection of the ſolar rays condenſed upon them." Tranſparent objects are alſo ſhewn with greater perfection than in the common ſolar microſcope.

Fig. 1, Plate V. repreſents the ſolar opake microſcope, mounted for exhibiting opake objects.

Fig. 2, is the ſingle tooth and pinion microſcope, which is uſed for ſhewing tranſparent objects; the cylindrical tube Y thereof being made to fit into the tube F E, Fig. 1.

Fig. 3, the ſlider which contains the magnifiers; it fits into a dove-tail which is at the upper part of the microſcope, Fig. 2.

A B C D E F, Fig. 1, repreſents the body of the ſolar microſcope; one part thereof, A B C D, is conical, the other, C D E F, is cylindrical. The cylindrical part receives the tube G of the opake box, or the tube Y of the ſingle microſcope, Fig. 2.

At the large end A B of the conical part, there is a lens to receive the rays from the mirror, and refract them towards the box H I K L.

N O P is a braſs frame, which is fixed to the moveable circular plate a b c; in this frame there is a plane mirror, to reflect the ſolar rays on the afore-mentioned lens.

This mirror may be moved into the moſt convenient poſition for reflecting the light, by means of the nuts Q and R.

By the nut Q it may be moved from eaſt to weſt; it may be elevated or depreſſed by the nut R.

d e, two ſcrews to faſten the microſcope to a window-ſhutter.

The box for opake objects is repreſented at H I K L; it contains a plane mirror M, for reflecting the light that it receives from the large lens to the object, and thereby illuminating it; S is a ſcrew to adjuſt this mirror, or place it at a proper angle for reflecting the light.

V X two tubes of braſs, one ſliding within the other, the exterior one in the box H I K L; theſe carry the magnifying lenſes: the interior tube is ſometimes taken out, and the exterior one is then uſed by itſelf. Part of this tube may be ſeen in the plate within the box H I K L.

At H there is a braſs plate, the back part of which is fixed to the hollow tube h, in which there is a ſpiral wire, which keeps the plate always bearing againſt the ſide H of the braſs box H I K L. The ſliders, with the opake objects, paſs between this plate and the ſide of the box; to put them there, the plate is to be drawn back by means of the nut g.

*i k*, a door to one ſide of the opake box.

The foregoing pieces conſtitute the ſeveral parts neceſſary for viewing opake objects. I ſhall now proceed to deſcribe the ſingle microſcope, which is uſed for tranſparent objects: but in order to examine theſe, the box H I K L muſt be firſt removed, and in it's place we muſt inſert the tube Y of the ſingle microſcope that we are now going to deſcribe.

Fig. 2, Plate V. repreſents a large tooth and pinion microſcope; at m, within the body of this microſcope, are two thin plates, that are to be ſeparated, in order to let the ivory ſliders paſs between them; they are preſſed together by a ſpiral ſpring, which bears up the under plate, and forces it againſt the upper one.

The ſlider, Fig. 3, that contains the magnifiers, fits into the hole n; any of the magnifiers may be placed before the object, by moving the aforeſaid ſlider: when the magnifier is at the center of the hole P, a ſmall ſpring falls into one of the notches which is on the ſide of the ſlider, Fig. 3.

Under the plate m are placed two lenſes, for enlarging the field of view on the ſcreen: the ſmaller of the two is fixed on a piece of braſs, and is neareſt the plate m; this is to be taken out, when the magnifiers, No. 4, 5, or 6, are uſed, or when the megalaſcope lens, Fig. 4, is uſed; but is to be replaced for No. 1, 2, 3.

This microſcope is adjuſted to the focus, by turning the milled nut O.

## TO USE THE SOLAR MICROSCOPE.

Make a round hole in the window-ſhutter, a little larger than the circle a b c; paſs the mirror C N P through this hole, and apply the ſquare plate to the ſhutter; then mark with a pencil the places which correſpond to the two holes through which the ſcrew is to paſs; take away the microſcope, and bore two holes at the marked places, ſufficiently large to let the milled ſcrews paſs through them.

Theſe ſcrews are to paſs from the outſide of the ſhutter, to go through it, and being then ſcrewed into their reſpective holes in the ſquare plate, they will, when ſcrewed home, hold it faſt againſt the inſide of the ſhutter, and thus ſupport the microſcope.

Screw the conical tube A B C D to the circle a b c, and then ſlide the tube G of the opake box into the cylindrical part C D E F of the body, if opake objects are to be examined; but if they be tranſparent objects you mean to ſhew, then place the tube Y within the tube C D E F.

The room is to be darkened as much as poſſible, that no light may enter but what paſſes through the body of the microſcope; for, on this circumſtance, together with the brightneſs of the ſunſhine, the perfection and diſtinctneſs of the image in a great meaſure depend.

I ſhall firſt conſider the microſcope as going TO BE USED FOR OPAKE OBJECTS. 1. Adjuſt the mirror N O P, ſo as to receive the ſolar rays, by means of the two finger ſcrews or nuts, Q, R; the firſt, Q, turns the mirror to the right or left; the ſecond, R, raiſes or depreſſes it: this you are to do till you have reflected the ſun's light through the lens at A B, ſtrongly upon a ſcreen of white paper, placed at ſome diſtance from the window, and formed thereon a round ſpot of light. An unexperienced obſerver will find it more convenient to obtain the light, by forming this ſpot before he puts on either the opake box, or the tooth and pinion microſcope.

Now put in the opake box, and place the object between the plates at H; open the door i k, and adjuſt the mirror M, till you have illuminated the object ſtrongly. If you cannot effect this by the ſcrew S, you muſt move the ſcrews Q, R, in order to get the light reflected ſtrongly from the mirror N O P, or the mirror M, without which the latter cannot illuminate the object.

The object being ſtrongly illuminated, ſhut the door i k, and a diſtinct view of the object will ſoon be obtained on your ſcreen, by adjuſting the tubes V X, which is effected by moving them backwards or forwards.

A round ſpot of light cannot always be procured in northern latitudes, the altitude of the ſun being often too low; neither can it be obtained when the ſun is directly perpendicular to the front of the room.

As the ſun is continually changing it's place, it will be neceſſary, in order to keep his rays full upon the object, to keep them continually directed through the axis of the inſtrument, by the two ſcrews Q and R.

To view tranſparent objects, remove the opake box, and inſert the tube Y of Fig. 2, Plate V. in it's place; put the ſlider, Fig. 3, Plate V. into it's place at n, and the ſlider, with the objects between the plates, at m; then adjuſt the mirror N O P, as before directed, by the ſcrews Q, R, ſo that the light may paſs through the object; regulate the focus of the magnifier by the ſcrew O. The moſt pleaſing magnifiers in uſe are the fourth and fifth.

The ſize of the object may be increaſed or diminiſhed, by altering the diſtance of the ſcreen from the microſcope: five or ſix feet is a convenient diſtance.

TO EXAMINE TRANSPARENT OBJECTS OF A LARGER SIZE, or to render the inſtrument what is uſually called a megalaſcope, take out the ſlider, Fig. 3, from it's place at n, and ſcrew the button, Fig. 4, into the hole at P, Fig. 2, and remove the glaſs which is under the plate at m, and regulate the light and focus agreeable to the foregoing directions.

N. B. At the end of the tube G there is a lens for increaſing the denſity of the rays, for the purpoſe of burning or melting any combuſtible or fuſible ſubſtance; this lens muſt be removed in moſt caſes, leſt the objects ſhould be burnt. The intenſity of the light is alſo varied by moving this tube backwards or forwards.

## APPARATUS OF THE OPAKE SOLAR MICROSCOPE.

The large ſquare plate and mirror.

The body of the microſcope.

The opake box and it's tube.

The tooth and pinion microſcope.

The ſlider with the magnifiers.

The megalaſcope magnifier.

The two ſcrews Q and R.

Some ivory ſliders.

Some ſliders with opake objects.

A braſs frame, with a bottom of ſoft deal to ſtick any object on.

A braſs cylinder K, Plate IX. for confining opake objects.

## Description of the common Solar Microscope,
## Fig. 4, Plate VI.

The foregoing deſcription will, in a great part, anſwer for this microſcope; and I once intended to have made only ſome general references to the former, in order to avoid that prolixity which muſt ever attend the detail of deſcription: but when I conſidered, that one of theſe inſtruments might be purchaſed by thoſe who would probably never ſee the other; and that a ſmall difference in conſtruction would embarraſs the young practitioner, it appeared to me more eligible to give a deſcription of the common ſolar at full length, than to curtail it through an affectation of brevity.

This inſtrument is repreſented in Plate VI. at the Figures 4, 5, 6, 7, 8.

A B C D, Fig. 4, repreſents the body of the microſcope, conſiſting of two braſs tubes. E F is the top of the inner moveable tube; the end e f of the ſingle tooth and pinion microſcope, Fig. 5, ſcrews into the top of this inner tube; at the end A B of the external tube there is a lens, to receive the light of the ſun from the mirror K L, and to collect and condenſe it on the object; the end A B ſcrews into the circular plate G H I.

K L, a long frame fixed to the moveable circular plate; in this frame there is a plane mirror to reflect the rays of the ſun on the lens at A B.

An endleſs worm or ſcrew, which is cut on the lower part of the nut M, works in a ſmall wheel which is fixed to the frame K L, ſo that by turning the nut, the frame K L is moved up or down: the nut N moves the mirror to the right or left.

O, P, two ſcrews to faſten the ſquare plate to the window-ſhutter.

Fig. 5, the ſingle microſcope; e f the end which ſcrews on to the upper part E of the internal tube of the body; q the dove-tailed ſlit for receiving the ſlider, Fig. 8.

g, the hole in which the megalaſcope magnifier, Fig. 6, is to be ſcrewed, when the ſlider, Fig. 8, is removed.

At h are the moveable plates, between which the ſliders are placed; under the lowermoſt of theſe the lens repreſented at Fig. 7 is

7 is to be placed, when the magnifiers, No. 1, 2, 3, and 4, are to be uſed.

e k is a ſmall piece of rack work, which is moved backwards and forwards by the pinion that is fixed to the lower end of the milled nut b: by the gradual motion of this rack, the objects are adjuſted to the foci of the different lenſes.

Fig. 8 is a braſs ſlider, with four or ſix lenſes or magnifying glaſſes; it is to be inſerted into the hole at q; either of the magnifiers may be placed before the object, by ſliding it one way or the other: you may perceive when the glaſs is in the center of the eye hole by a ſmall ſpring falling into a notch which is made on the ſide of the ſlider oppoſite to each lens.

## TO USE THE SOLAR MICROSCOPE.

Faſten the ſquare plate againſt the inſide of a window-ſhutter, by the two ſcrews O, P, which are to go from the outſide of the window-ſhutter through it, and then be ſcrewed into their reſpective holes in the ſquare plates G H I. The mirror is to be on the outſide of the ſhutter, paſſing through a hole made for that purpoſe.

Darken the room; then place a ſcreen at a convenient diſtance from the window, the farther it is from it the larger is the image: now move the mirror K L by the two nuts M, N, till the ſun's rays come through the inſtrument in an horizontal direction to the ſcreen, forming a round ſpot thereon; ſcrew the microſcope, Fig. 5, into it's place E F; put the ſlider, with the lens, Fig. 8, in it's proper ſituation, and the object ſlider between the plates at h; adjuſt the object to the focus of the magnifying lens by the ſcrew b, till the object appears diſtinct and clear on the ſcreen. By moving the internal tube of the body, the object may be placed at different diſtances from the lens which is fixed at A B, ſo as to be ſufficiently illuminated, and yet not ſcorched by the ſolar rays.

### APPARATUS BELONGING TO THE COMMON SOLAR MICROSCOPE.

Square plate and mirror.

The body, conſiſting of two tubes, one within the other.

The ſingle microſcope.

The megalaſcope lens, Fig. 6.

The ſlider, Fig. 8, with ſix lenſes.

The two ſcrews O, P.

Six ivory ſliders and a talc box.

Some glaſs tubes.

A ſlider, or braſs caſe, containing a plane piece of glaſs, and a braſs ſlider with holes, into which are cemented ſmall concave glaſſes, deſigned for confining ſmall inſects between the plane and concave glaſs, which are thus preſerved from being cruſhed, and prevented from wandering out of the field of view.

### THE SCREW BARREL, OR WILSON'S SINGLE POCKET MICROSCOPE, Fig. 1 and 2, Plate II. B.

This microſcope of Mr. Wilſon's is an invention of many years ſtanding, and was in ſome meaſure laid aſide, till Dr. Lieberkuhn introduced the ſolar apparatus, to which he applied it, there being no other inſtrument at that time which would anſwer his purpoſe ſo well; ſince which time it has been revived, and much eſteemed, though very troubleſome in many caſes.

The body of the microſcope is repreſented by A B, Fig. 1, and is made either of ſilver, braſs, or ivory.

C C is a long fine-threaded male ſcrew that turns into the body of the microſcope.

D, a convex glaſs at the end of the ſaid ſcrew, on which may be placed, as occaſion requires, one of the two concave pieces of thin braſs, with holes of different diameters in the center of them, to cover the ſaid glaſs, and thereby diminiſh the aperture when the greateſt magnifiers are uſed.

E, three thin plates of braſs within the body of the microſcope, one whereof is bent ſemicircularly in the middle, ſo as to form an arched cavity for the reception of a tube of glaſs.

F, a piece of wood or braſs, arched in the manner of the ſaid plate, and faſtened thereto.

G, the other end of the microſcope, where a hollow female ſcrew is adapted to receive the different magnifiers.

H, a ſpiral ſpring of ſteel between the ſaid end G and the plates of braſs E, intended to keep the plates in a due poſition, and counteract againſt the long ſcrew C.

I, a ſmall turned handle, for the better holding the inſtrument, which ſcrews on and off at pleaſure.

To this microſcope belong ſeven different magnifying glaſſes, ſix of which are ſet either in ſilver, braſs, or ivory, as in the figure K, and are marked 1, 2, 3, 4, 5, 6: obſerve, the loweſt numbers are the greateſt magnifiers. L is the ſeventh magnifier, ſet in the manner of a little barrel, to be held in the hand for viewing any larger object.

M is a flat ſlip of ivory, called a ſlider, with four round holes through it, wherein to place objects between two muſcovy talcs.

Six ſuch ivory ſliders, and one of braſs, are uſually ſold with this microſcope, ſome with objects placed in them, and others empty, for viewing any thing that may offer; but whoever pleaſes to make a large collection of objects, may have as many as he deſires. There is alſo a braſs ſlider, not expreſſed in the figure, to confine any ſmall object, that it may be viewed without cruſhing or deſtroying it.

N is a pair of forceps, or pliers, for the taking up of inſects or other objects, and adjuſting them in the glaſſes.

O, a little hair bruſh or pencil, wherewith to take up and examine a ſmall drop of liquid.

P is a tube of glaſs to confine living objects, ſuch as frogs, fiſhes, &c. in order to diſcover the circulation of the blood.

When you would view an object, thruſt the ivory ſlider, in which the ſaid object is placed, between the two flat braſs plates, obſerving always to put that ſide of the ſlider where the braſs rings are fartheſt from the eye; then ſcrew in the magnifying glaſs you intend to uſe at the end of the inſtrument G, and looking through it againſt the light, turn the long ſcrew C C till your object is brought to the true focal diſtance, which you will know by it's appearing perfectly clear and diſtinct.

The way of examining any object accurately, is to look at it, firſt, through a magnifier that will ſhew the whole at once, and afterwards to inſpect the ſeveral parts more particularly with one of the greateſt magnifiers; for thus you will gain a true idea of the whole, and all it's parts: and though the greateſt magnifiers can ſhew but a minute portion of any object at once, ſuch as the claw of a flea, the horn of a louſe, or the like, yet by gently moving the ſlider that contains your object, the eye will gradually ſee the whole; and if any part ſhould be out of the focal diſtance, the ſcrew C C will eaſily bring it to the true focus.

As objects muſt be brought very near the glaſſes when the greateſt magnifiers are uſed, be particularly careful not to ſcratch them, by rubbing the ſlider againſt them as you move it in or out. A few turns of the ſcrew C C will eaſily prevent this miſchief, by giving it room enough.

## DESCRIPTION OF A SCROLE FOR FIXING WILSON'S POCKET MICROSCOPE, AND REFLECTING LIGHT TO IT BY A MIRROR.

A B C, Fig. 2, is a braſs ſcrole, which, for the better conveniency of carriage, is ſo ordered as to take into three parts, and put into the drawer upon which it ſtands, with it's reflecting mirror and Wilſon's pocket microſcope.

The top part of the ſcrole is taken off at B, by unſcrewing half a turn of the ſcrew; then lift it up, and it comes out of the ſocket. The lower part unſcrews at C, and the baſe unſcrews at E.

The mirror lifts out at F, which, with the ſcrole, lie in one partition of the box.

To apply this ſcrole to uſe, fix the body of the microſcope to the top thereof by the ſcrew A, as in Fig. 2, by ſcrewing it in the ſame hole as the ivory handle.

The braſs or ivory ſlider being fixed as before deſcribed, and the microſcope placed in a perpendicular poſition, move the reflecting glaſs D in ſuch a manner as to caſt the light of the ſky, the ſun, or a candle, directly upwards through the microſcope; by which means it is made to anſwer moſt of the ends of a double reflecting microſcope.

It is alſo rendered more uſeful for viewing opake objects by ſcrewing the arm Q R, Fig. 1, into the body of the microſcope at G; then ſcrewing into the round hole R that magnifier which you think will beſt ſuit your object, and putting the concave ſpeculum S, on to the outſide of the ring R, you will find in the body of the microſcope, between the wood or braſs F, and the end of the male ſcrew C C, a ſmall hole u, through which ſlides the long wire T, which has a point at one end and forceps at the other, that may be uſed occaſionally, as your object requires: when you have fixed this, and your object on it, turn the arm R, which is performed by two motions, till the magnifier is brought over the object; it may be then adjuſted to the true focus, by turning the male ſcrew C C in the ſame manner as before deſcribed. It muſt alſo be turned exactly over the ſpeculum, by twiſting the upper part of the ſcrole to one ſide, till your object and the two ſpeculums are in one line, as will be found by trial; and then fix it by the ſcrew B, at which time the upper ſurface of the object will be ſo exceedingly enlightened by the light reflected upward from the mirror to the concave ſpeculum, as to be ſeen as clear and diſtinct as any tranſparent one.

## DESCRIPTION OF A SMALL MICROSCOPE FOR OPAKE OBJECTS, Fig. 3 and 4, Plate II. B.

A, Fig. 4, is a fixed arm, through which paſſes a ſcrew B, the other end whereof is faſtened to the moveable arm C.

D is a nut fitted to the ſaid ſcrew, which, when turned, will either ſeparate or bring together the two arms A C.

E is a ſteel ſpring, that ſeparates the two ſides when the nut is unſcrewed.

F, a piece of braſs turning round in a ſocket, whence proceeds a ſpringing tube, moving on a rivet, through which runs a ſteel wire, one end of which finiſhes in a point G, and the other end hath a pair of pliers H ſoldered to it; theſe are either to thruſt into, or to take up and hold any object, and may be turned round as required.

I, a ring of braſs, with a female ſcrew fixed on an upright piece of the ſame metal, which turns on a rivet, that it may be ſet at a due diſtance when the leaſt magnifiers are uſed, and ſerves the ſcrews of all the magnifiers.

K, a concave ſpeculum of ſilver, poliſhed as bright as poſſible, in the center of which a double convex lens is placed, with a proper aperture to look through it. On the back of this ſpeculum a male ſcrew L is made to fit the braſs ring I, which may be ſcrewed into the ſaid ring at pleaſure.

Four of theſe concave ſpecula, of different depths, are fitted to four glaſſes of different magnifying powers, to be uſed as the objects to be examined may require. The greateſt magnifiers have the leaſt apertures.

M, a round object plate, one ſide white, and the other black, intended to render objects the more viſible, by placing them, if black, upon the white, and if white, on the black ſide.

A ſteel ſpring N turns down on each ſide, to make any object faſt: from the object plate there is a hollow pipe, to ſcrew it on the needle's point G.

O, a ſmall box of braſs, with a glaſs on each ſide, contrived to confine any living object in order to examine it; this alſo has a pipe to ſcrew upon the end of the needle at G.

P, a turned handle of ivory, to ſcrew into the inſtrument when it is made uſe of.

Q, a pair of pliers to take up any object, or manage it with conveniency.

R, a ſoft hair bruſh, to clean the glaſſes or ſpecula.

When you would view any object, ſcrew the ſpeculum, with the magnifier you intend to uſe, into the braſs ring I; place your object either on the needle G, in the pliers H, on the object plate M, or in the braſs hollow box O, as may be moſt convenient, according to the nature and condition of it; then holding up your inſtrument by the handle P, look againſt the light through the magnifying lens, and by means of the nut D, together with the motion of the needle, by managing it's lower end, the object may be turned about, raiſed or depreſſed, brought nearer the glaſs, or put farther from it, till you hit the true focal diſtance, and the light be ſeen reflected from the ſpeculum ſtrongly upon the object, by which means it will appear very diſtinct and clear.

## OF ELLIS'S SINGLE OR AQUATIC MICROSCOPE, Plate VII. B.

This inſtrument takes it's name from Mr. John Ellis, author of "An Eſſay towards a Natural Hiſtory of Corallines," and of the "Natural Hiſtory of many curious and uncommon Zoophytes." This was the inſtrument that he made uſe of, and by which he was enabled to explain many ſingularities in the œconomy and conſtruction of theſe wonderful productions of nature. To the practical botaniſt this inſtrument is recommended, by the reſpectable authority of Mr. Curtis, author of the Flora Londinenſis, a work which does credit to the author and the nation. This microſcope is ſimple in it's conſtruction, eaſy in it's uſe, and very portable; theſe advantages, as well as ſome others which it alſo has over every other portable microſcope, have accelerated the ſale thereof, and cauſed it to be very much adopted.

## DESCRIPTION OF THE VARIOUS PARTS OF THE MICROSCOPE.

K, the box which contains the whole apparatus; it is generally made of fiſh-ſkin; on the top of the box there is a female ſcrew, for receiving the ſcrew which is at the bottom of the pillar A, a pillar of braſs which is ſcrewed on the top of the box K.

D, a braſs pin which fits into the pillar; on the top of this pin is a hollow ſocket to receive the arm which carries the magnifiers;

the pin is to be moved up and down, in order to adjuſt the lenſes to their focal or proper diſtance from the object.

N. B. In the repreſentation of this microſcope, Plate VII. B. Fig. 1, the pin D is delineated as paſſing through a ſocket at one ſide of the pillar A; whereas it is uſual at preſent to make it paſs down a hole bored through the middle of the pillar.

E, the bar which carries the magnifying lens; it fits into the ſocket X which is at the top of the pillar D. This arm may be moved backwards and forwards in the ſocket X, and ſideways by the pin D, ſo that the magnifier, which is ſcrewed into the ring at the end E of this bar, may be eaſily made to traverſe over any part of the object that lays on the ſtage or plate B.

E F is a poliſhed ſilver ſpeculum, with a magnifying lens, placed at the center thereof, which is perforated for this purpoſe. The ſilver ſpeculum ſcrews into the arm E as at F.

G, another ſpeculum, with it's lens, which is of a different magnifying power from the former.

H, the ſemicircle which ſupports the mirror I; the pin R, affixed to the ſemicircle H, paſſes through the hole which is towards the bottom of the pillar A.

B, the ſtage, or the plane, on which the objects are to be placed; it fits into the ſmall dove-tailed arm which is at the upper end of the pillar D A.

C, a plane glaſs, with a ſmall piece of black ſilk ſtuck on it; this glaſs is to lay in a groove made in the ſtage B.

M, a hollow glaſs, to be laid occaſionally on the ſtage inſtead of the plane glaſs C.

L, a pair of nippers. Theſe are fixed to the ſtage by the pin R; the ſteel wire of theſe nippers ſlides backwards and forwards in the ſocket, and this ſocket is moveable upwards and downwards by means of the joint, ſo that the poſition of the object may be varied at pleaſure. The object may be fixed in the nippers, ſtuck on the point, or affixed by a little gum water, &c. to the ivory cylinder N.

O, a ſmall pair of forceps to take up ſmall objects.

P, a bruſh to clean the glaſſes.

### TO USE ELLIS'S MICROSCOPE.

Take all the parts of the apparatus out of the box; then begin by ſcrewing the pillar A to the cover thereof; paſs the pin R of the ſemicircle which carries the mirror through the hole that is near the bottom of the pillar A; puſh the ſtage into the dove-tail at B, ſlide the pin into the pillar, (ſee the N. B. above) then paſs the bar E through the ſocket which is at the top of the pin D, and ſcrew one of the magnifying lenſes into the ring at F. The microſcope is now ready for uſe; and though the enumeration of the articles may lead the reader to imagine the inſtrument to be of a complex nature, we can ſafely affirm, that he will find it otherwiſe. The inſtrument has this peculiar advantage, that it is difficult to put any of the pieces in a place which is appropriated to another.

Let the object be now placed either on the ſtage or in the nippers L, and in ſuch manner, that it may be as nearly as poſſible over the center of the ſtage: bring the ſpeculum F over the part you mean to obſerve; then throw as much light on the ſpeculum as you can, by means of the mirror I L, and the double motion of which it is capable; the light received on the ſpeculum is reflected by it on the object. The diſtance of the lens F from the object is regulated by moving the pin D up and down, until a diſtinct view of it is obtained. The rule which I obſerve is, to place the lens beyond it's focal diſtance from the object, and then gradually ſlide it down, till the object appears ſharp and well defined. The adjuſtment of the lenſes to their focus, and the diſtribution of the light on the object, are what require the moſt attention; on the firſt the diſtinctneſs of the viſion depends; the pleaſure ariſing from a clear view of the parts under obſervation, is due to the modification of the light. No preciſe rule can be given for attaining accurately theſe points; it is from practice alone that ready habits of obtaining theſe neceſſary properties can be acquired; with the aſſiſtance of this no difficulty will be found.

Theſe microſcopes are ſometimes fitted up with a toothed rack and pinion, for the more ready adjuſtment of the glaſſes to their proper focus.

## DESCRIPTION OF LYONET'S ANATOMICAL MICROSCOPE, Fig. 3, Plate VI.

Fig. 3 repreſents the inſtrument with which M. Lyonet made his microſcopical and wonderful diſſection of the chenille de ſaule, of which a ſpecimen is given in Plate XII. Fig. 1, &c. of this work. This little inſtrument needs no further recommendation; aided by it, other obſervers may be enabled to diſſect other inſects with the ſame accuracy as M. Lyonet, and thus advance the knowledge of comparative anatomy, by which alone the characteriſtic, nature, and rank of animals, can be truly aſcertained.

A B is the anatomical table, which is ſupported by the pillar N O; this is ſcrewed on the foot C D. The table A B is prevented from turning round, by means of two ſteady pins; in this table or board there is a hole G, which is exactly over the center of the mirror E F, that is to reflect the light on the object; the hole G is deſigned to receive a flat or concave glaſs, on which the objects are to be placed that you deſign to examine.

R X Z is an arm formed of ſeveral balls and ſockets, by which means it may be moved in every poſſible ſituation; it is fixed to the board by means of the ſcrew H; the laſt arm I Z has a female ſcrew, into which a magnifier may be ſcrewed as at Z. By means of the ſcrew H, a ſmall motion may be occaſionally given to the arm I Z, for adjuſting the lens with accuracy to it's focal diſtance from the object.

Another chain of balls is ſometimes uſed, carrying a lens to throw light upon the object; the mirror is alſo ſo mounted, as to be taken from it's place at K, and fitted on a clamp, by which it may be fixed to any part of the table A B.

## TO USE THE DISSECTING TABLE.

Let the operator ſet with his left ſide near a light window; the inſtrument being placed on a firm table, the ſide D H towards the ſtomach, the obſervations ſhould be made with the left eye; this poſition is well adapted for obſerving drawing or writing. In diſſecting, the two elbows are to be ſupported by the table on which the inſtrument reſts, the hands reſting againſt the board A B; in order to give it greater ſtability, (as a ſmall ſhake, though imperceptible to the naked eye, is very viſible in the microſcope) the diſſecting inſtruments are to be held one in each hand, between the thumb and two fore-fingers. Other circumſtances will be learnt from practice; and more will be ſaid on the mode of diſſecting ſmall objects in the following chapter.

## DESCRIPTION OF DR. WITHERING'S BOTANICAL MICROSCOPE, Fig. 1, Plate VI.

This little inſtrument is repreſented at Fig. 1, Plate VI. It conſiſts of three braſs plates, A, B, C, which are parallel to each other; the wires D and E are rivetted into the upper and lower plate, which are by this means united to each other; the middle plate or ſtage is moveable on the aforeſaid wires, by two little ſockets which are fixed to it.

The two upper plates each contain a magnifying lens, but of different powers: one of theſe confines and keeps in their places the fine point F, the forceps G, and the ſmall knife H.

To uſe this inſtrument, unſcrew the upper lens, and take out the point, the knife, and the forceps; then ſcrew the lens on again, place the object on the ſtage, and then move it up or down till you have gained a diſtinct view of the object, as one lens is made of a ſhorter focus than the other; and ſpare lenſes, of a ſtill deeper focus, may be had if required. This little microſcope is the invention of Dr. Withering, and is deſcribed by him in his "Botanical Arrangements." It's principal merit is it's plicity.

## COMMON BOTANICAL MICROSCOPE.

This little inſtrument is repreſented at Fig. 2, Plate VI. It appears to me preferable to Dr. Withering's, being equally ſimple, more extenſive in it's application, and the ſtage unincumbered; though that of M. Lyonet ſeems better adapted than either to the purpoſes of diſſection.

A B, a ſmall arm, carrying the two magnifiers, one fixed to the upper part as at B, the other to the lower part of the arm at C; theſe may be uſed ſeparately or combined together. The arm A B is ſupported by the ſquare pillar I K, the lower end of which fits into the ſocket E of the foot F G; the ſtage D L is made to ſlide up and down the ſquare pillar; H, a concave mirror for reflecting light on the object.

To uſe this microſcope, place the object on the ſtage, reflect the light on it from the concave mirror, and regulate it to the focus, by moving the ſtage nearer to or further from the lens at B. The ivory ſliders paſs through the ſtage; other objects may be fixed in the nippers L M, and then brought under the eye-glaſſes; or they may be laid on one of the glaſſes which fit the ſtage.

The apparatus to this inſtrument conſiſts of three ivory ſliders, a pair of nippers, a pair of forceps, a flat glaſs, and a concave ditto, both fitted to the ſtage.

## BOTANICAL MAGNIFIERS.

Since botany has been cultivated with ſo much ardor, it has been found neceſſary to contrive ſome very portable inſtrument, by which the botaniſt might inveſtigate the object of his purſuits, as it riſes before him. Figures 7 and 8, Plate VIII. repreſent two, the moſt convenient of this kind.

In the caſe, Fig. 8, are three lenſes, *g*, *h*, *i*, of different magnifying powers, that all turn up and ſhut into the caſe.

Fig. 7 contains alſo three lenſes, *a*, *b*, *d*, of different foci, which are all made to turn into the caſe, and may be uſed combined or ſeparately.

The three lenſes in themſelves afford three different magnifying powers; by combining two and two we make three more; the three together make a ſeventh magniſying power with three lenſes. When the three lenſes are uſed together, it is beſt to turn them into the caſe, and look through the hole, as this combined magnifying power is ſo great, that it requires to have a portion of the light which falls on the lenſes excluded, in order to attain diſtinct viſion. Further, the eye is alſo by this means made to coincide more eaſily with the axis of the glaſſes.

## DESCRIPTION OF A PORTABLE MICROSCOPE AND TELESCOPE, Fig. 1, 2, 3, 4, 5, 6, Plate VIII.

The teleſcope is one of thoſe which are compoſed of ſeveral ſliding drawers or tubes, for the convenience of being put in the pocket; the ſliding tubes are made of thin braſs, the outſide tube of mahogany.

The ſliding tubes are contrived to ſtop when drawn out to a proper length, ſo that by applying one hand to the outſide tube, and the other hand to the end of the ſmalleſt tube, the teleſcope may be at one pull drawn out it's whole length; then any of the tubes (that next the eye is moſt generally uſed) may be puſhed in gradually while you are looking through, till the object is rendered diſtinct to the ſight.

To make the tubes ſlide properly, they all paſs through ſhort ſprings or tubes; theſe ſprings may be unſcrewed from the ends of the ſliding tubes by means of the milled edges which project above the tubes, and the tubes taken from each other if required, and the ſpring ſet cloſer if it is too weak.

Fig. 5 repreſents the exterior tube of the teleſcope, which is to be unſcrewed from the reſt, as it does not make any part of the microſcope; the cover k, which protects the object-glaſs, ſerves alſo as a box to contain the ſliders with the objects, and a ſmall mirror.

Fig. 4 is a view of this cover when taken off: unſcrew the top part of it, and the mirror, Fig. 6, may be taken out; unſcrew the cover of the lower part, and you will find therein the two circular ſliders repreſented at Fig. 1 and 2.

Fig. 3 repreſents the three internal tubes of the teleſcope, which conſtitute the microſcopic part thereof. Draw the tubes out in the manner that is ſeen in Fig. 3; then on the inſide, but at the lower end of the exterior tube, you will find a ſhort tube, which ſerves as a ſtage to hold the object and ſupport the mirror; pull this tube partly out, and turn it, ſo that a circular hole which is pierced in it may coincide with a ſimilar hole in the exterior tube. This tube is repreſented as drawn out at Fig. 3, the mirror, Fig. 4, placed therein at L M, and the tranſparent ſlider fixed at N O.

Fig. 1 repreſents the ſlider with tranſparent objects.

Fig. 2, that with opake. They are made of ivory, and turn on a pin at the center; the ſlit end of this pin fits on the edge of the tube, which is then to be puſhed up, ſo that the lower end of the exterior tube may bear lightly on the upper ſide of the ſlider, agreeable to the view which is given at Fig. 3. Now puſh down the ſecond tube till the milled part falls on the milled edge of the exterior tube, being careful of the circular hole in the exterior one. Nothing now remains to be done but to adjuſt for the focus, which is effected by puſhing down the tube T V till the object appears diſtinct.

The inſtrument may be uſed in two ways for tranſparent objects; firſt, in a vertical poſition, when the light is to be thrown on the object by the mirror L M; or it may be examined by looking up directly at the light; in the latter caſe the mirror muſt be taken away.

In viewing opake objects the mirror is of no uſe; as much light as poſſible muſt be let fall on them through the circular holes of the tubes.

Any object may be viewed by firſt puſhing the tube I R, and then bringing the tube T to it's focal diſtance from the object.

## A DESCRIPTION OF THOSE PARTS OF A MICROSCOPICAL APPARATUS, WHICH ARE DELINEATED IN Plate IX.

A and B repreſent the braſs cells which contain the magnifiers belonging to the different kinds of compound microſcopes. The magnifiers are ſometimes contained in a ſlider like that which is delineated at Fig. 3, Plate V. The lenſes of A and B are confined by a ſmall cap; on unſcrewing this, the ſmall lens may be taken out and cleaned. The magnifiers A of the lucernal microſcope are ſo contrived, that any two of them may be ſcrewed together, by which means a conſiderable variety of magnifying power is obtained.

To get at the lenſes in the ſlider, Fig. 3, Plate V. take out the two ſcrews which hold on the cover.

C, Plate IX. repreſents the general form of the ſlider-holder. It conſiſts of a cylindrical tube, in which an inner tube is forced up by a ſpring. It is uſed to receive the ivory or any other ſlider, in which the tranſparent objects are placed; theſe are to be ſlid between the two upper plates: the hollow part in one of the plates is deſigned for the glaſs tubes.

D, the condenſing lens and it's tube, which fits into the ſlider-holder C, and may be moved up and down in it. When this piece is puſhed up as far as it will go, it condenſes the light of a candle, which is reflected on it by the plain mirror of the compound microſcope, and ſpreads it uniformly over the object; in this caſe it is beſt adapted to the ſhalloweſt magnifiers. If the deeper lenſes are uſed, it ſhould be drawn down, or rather removed further from the object, that it may concentrate the light in a ſmall compaſs, and thus render it more denſe. The condenſing lens is ſometimes fitted up differently, but the principle being the ſame, it will be eaſy to apply it to uſe, notwithſtanding ſome variations in the mechaniſm.

E, a braſs cone; it fixes under the ſlider-holder. It is uſed to leſſen occaſionally the quantity of light which comes from the mirror to any object.

F, a box, with two flat glaſſes, which may be placed at different diſtances from each other, in order to confine a ſmall living inſect.

G, a ſmall braſs box to hold the ſilver ſpeculum H.

H, a ſmall ſilver concave ſpeculum, deſigned to reflect the light from the mirror on opake objects; it ſhould only be uſed with the ſhallow magnifiers. It is applied in different ways to the compound microſcope; ſometimes to a tube ſimilar to that repreſented at X, which ſlides on the lower part of the body; ſometimes it is ſcrewed into the ring of the piece Q; the pin of this generally fits into one of the holes in the ſtage. When this ſpeculum is uſed, the ſlider-holder ſhould be removed.

I, a fiſh-pan, whereon a ſmall fiſh may be faſtened, in order to view the circulation of the blood; it's tail is to be ſpread acroſs the oblong hole at the ſmalleſt end, and tied faſt by means of the ribbon fixed thereto, by ſhoving the knob which is on the back of it through the ſlit made in the ſtage; the tail of the fiſh may be brought under the lens which is in uſe.

K, a cylindrical piece, intended for the ſolar opake microſcope; by pulling back the ſpiral ſpring, ſmaller or larger objects may be confined in it.

L, a long ſteel wire, with a ſmall pair of pliers at one end, and a ſteel point at the other; the wire ſlips backwards or forwards in a ſpring tube, which is affixed to a joint, at the bottom of which is a pin to fit one of the holes in the ſtage; this piece is uſed to confine ſmall objects.

l, a ſmall ivory cylinder that fits on the pointed end of the ſteel wire L; it is deſigned to receive opake objects. Light-coloured ones are to be ſtuck on the dark ſide, and vice verſa.

K 2 is a pair of triangular nippers, for taking hold and confining a large object.

M, a convex lens, which fits the ſtage by means of the long pin adhering to it; it is deſigned to collect the light from the ſun or a candle, and to throw them on any object placed on the ſtage: this piece is very little uſed at preſent.

N, a braſs ſlider, into which is fitted a flat piece of glaſs, and a braſs ſlider, containing one or two ſmall concave glaſſes, the others flat; it is deſigned to confine ſmall living objects, and when uſed is to be placed between the two upper plates of the ſlider-holder.

O, a glaſs tube to receive a ſmall fiſh, &c.

P repreſents one of the ivory-ſliders, wherein objects are placed between two pieces of talc, and confined by a braſs ring.

Q, a piece to hold the ſpeculum H; this piece is generally fitted to the microſcopes which are repreſented at Fig. 1 and 2, Plate IV.

R, a pair of forceps, to take up any occaſional object.

S, a camel's hair pencil to bruſh the duſt off the glaſſes; the upper part of the quill is ſcooped out, to take up a drop of any fluid, and place it on either of the glaſſes for examination.

T, an inſtrument for cutting thin tranſverſe ſections of wood. It conſiſts of a wooden baſe, which ſupports four braſs pillars; on the top of the pillars is placed a flat piece of braſs, near the middle of which there is a triangular hole.

A ſharp knife, which moves in a diagonal direction, is fixed on the upper ſide of the afore mentioned plate, and in ſuch a manner, that the edge always coincides with the ſurface thereof.

The knife is moved backwards and forwards by means of the handle a. The piece of wood is placed in the triangular trough, which is under the braſs plate, and is to be kept ſteady therein, by a milled ſcrew which is fitted to the trough; the wood is to be preſſed forward for cutting by the micrometer ſcrew b.

The pieces of wood ſhould be applied to this inſtrument immediately on being taken out of the ground, or elſe they ſhould be ſoaked for ſome time in water, to ſoften them ſo that they may not hurt the edge of the knife.

When the edge of the knife is brought in contact with the piece of wood, a ſmall quantity of ſpirits of wine ſhould be poured on the ſurface of the wood, to prevent it's curling up; it will alſo make it adhere to the knife, from which it may be removed by preſſing a piece of blotting-paper on it.

Y is an appendage to the cutting engine, which is to be uſed inſtead of the micrometer ſcrew, being preferred by ſome practitioners to it. It is placed over the triangular hole, and kept flat down upon the ſurface of the braſs plate, while the piece of wood is preſſed againſt a circular piece of braſs which is on the under ſide of it.

This circular piece of braſs is fixed to a ſcrew, by which it's diſtance from the flat plate on which the knife moves may be regulated.

Z, an ivory box, containing at one end ſpare talc for the ivory ſliders, and at the other ſpare rings, for preſſing the talcs together and confining them to the ſlider.

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CHAP.

# CHAP. IV.

## GENERAL INSTRUCTIONS FOR USING THE MICROSCOPE, AND PREPARING THE OBJECTS.

AS the advantages which are obtained from any inſtrument are conſiderably increaſed, if it be uſed by a perſon who is maſter of it's properties, attentive to it's adjuſtments, and habituated by practice to the minutiæ of management, it is the deſign of this chapter to point out thoſe circumſtances which require moſt the attention of the obſerver, and to give ſuch plain directions, as may enable him to examine any object with eaſe; to ſhew how he may place it in the beſt point of view, and, if neceſſary, prepare it for obſervation.

A ſmall degree of attention will render the obſerver maſter of every neceſſary rule, and a little practice will make them familiar and habitual: the pains he takes to acquire theſe habits will be rewarded by an increaſing attachment to his inſtrument, and the wonders it diſplays. Let him only perſevere till he has overcome that natural indolence which oppoſes the advancement of every kind of knowledge, and he will ſurely find himſelf moſt amply recompenſed, by the pleaſure of a ſcience that has the unlimited treaſures of INFINITE WISDOM for the object of it's

reſearches:

reſearches: and his mind being ſtrengthened by the victory it has gained, will be more keen in perceiving, and more patient in the inveſtigation of truth.

It has long been a complaint,* that many of thoſe who purchaſe microſcopes are ſo little acquainted with their general and extenſive uſefulneſs, and ſo much at a loſs for objects to examine by them, that after diverting their friends ſome few times with what they find in the ſliders, which generally accompany the inſtrument, or perhaps two or three common objects, the microſcope is laid aſide as of little further value: whereas no inſtrument has yet appeared in the world capable of affording ſo conſtant, various, and ſatisfactory an entertainment to the mind. This complaint will, I hope, be obviated by theſe eſſays, in which I have endeavoured to make the uſe of the microſcope eaſy, point out an immenſe variety of objects, and direct the obſerver how to prepare them for examination.

The ſubject treated of in this chapter naturally divides itſelf into three heads: 1. concerning the neceſſary preparation and adjuſtment of the microſcope; the 2nd, treating of the proper quantity of the light, and beſt method of adapting it to the objects under examination; the 3d, ſhewing how to prepare and preſerve the various objects, that their nature, organization, and texture, may be properly underſtood.

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* Baker's Microſcope made Eaſy, p. 51.

## OF THE NECESSARY PREPARATION OF THE MICROSCOPE FOR OBSERVATION.

We have in the laſt chapter explained thoſe particulars that conſtitute the difference of one microſcope from another, and ſhewn how each inſtrument is to be uſed, and how the ſeveral parts are to be applied to it. We ſhall now proceed to give ſome general directions applicable to every microſcope. The obſerver is therefore ſuppoſed to have made himſelf maſter of his inſtrument, and to know how to adapt the different parts of the apparatus to their proper places.

The firſt circumſtance neceſſary to be examined into is, whether the different glaſſes belonging to the microſcope are perfectly clean or not; if they are not clean, they muſt be taken out and wiped with a piece of waſh leather, taking care at the ſame time not to ſoil the ſurface of the glaſs with the fingers: in replacing the glaſſes, you muſt alſo be careful not to lay them in an oblique ſituation.

The object ſhould be brought as near the center of the field of view as poſſible, for there only will it be exhibited in the greateſt perfection.

The eye ſhould be moved up and down from the eye-glaſs of a compound microſcope, till you find that ſituation where the largeſt field and moſt diſtinct view of the object is obtained. Every perſon ought to adjuſt the microſcope to his own eye, and not depend upon the ſituation it was placed in by another.

Care muſt be taken not to let the breath fall upon the eye-glaſs, nor to hold that part of the body of the microſcope where the glaſſes are placed with a warm hand, becauſe the damp that is expelled from the metal by the heat will be attracted and condenſed by the glaſſes, and obſtruct the ſight of the object.

The obſerver ſhould always begin with a ſmall magnifying power; with this he will gain an accurate idea of the ſituation and connection of the whole, and will therefore be leſs liable to form any erroneous opinion, when the parts are viewed ſeparately by a deeper lens. By a ſhallow magnifier he will alſo diſcover thoſe parts which merit a further inveſtigation.

Every object ſhould, if poſſible, be examined firſt in that poſition which is moſt natural to it: if this circumſtance is neglected, very inadequate ideas of the ſtructure of the whole, as well as of the connection and uſe of the parts, will be formed. If it be a living animal, care muſt be taken not to ſqueeze, hurt, or diſcompoſe it.

There is a great difference between merely viewing an object by the microſcope, and inveſtigating it's nature: in the firſt we only conſider the magnified repreſentation thereof, in the ſecond we endeavour to analyſe and diſcover it's nature and relation to other objects. In the firſt caſe, we receive the impreſſion of an image formed by the action of the glaſſes; in the ſecond, we form our judgment by inveſtigating this image. It is eaſy to view the image which is offered to the eye, but not ſo eaſy to form a judgment of the things that are ſeen; an extenſive knowledge of the ſubject, great patience, and many experiments, will be found neceſſary for this purpoſe: for there are many circumſtances where the images ſeen may be very ſimilar, though originating from ſubſtances totally different; it is here the penetration of the obſerver will be exerciſed, to diſcover the difference, and avoid error.*

Hence Mr. Baker † cautions us againſt forming an opinion too ſuddenly of any microſcopic object, and not to draw our inferences till after repeated experiments and examinations of the object, in all lights and various poſitions; to paſs no judgment upon things extended by force, or contracted by dryneſs, or in any manner out of a natural ſtate, without making ſuitable allowances.

The true colour of objects cannot be properly determined when viewed through the deepeſt magnifiers; for, as the pores and interſtices of an object are enlarged, according to the magnifying power of the glaſſes made uſe of, the component particles of it's ſubſtance will appear ſeparated many thouſand times farther aſunder than they do to the naked eye: it is, therefore, very probable, that the reflection of the light from theſe particles will be very different, and exhibit different colours.

Some conſideration is alſo neceſſary in forming a judgment of the motion of living creatures, or even of fluids, when ſeen through the microſcope; for as the moving body, and the ſpace wherein it moves, are magnified, the motion will alſo be increaſed.

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* Fontana ſur les Poiſons, vol. ii. p. 245.

† Baker's Microſcope made Eaſy, p. 62.

If an object is ſo opake as not to ſuffer any light to paſs through it, as much as poſſible muſt be thrown on it's upper ſurface by that part of the apparatus which is peculiarly adapted for opake objects. As the apertures of deep magnifiers are but ſmall, and conſequently admit but little light, they are not proper for the examination of opake objects: this, however, naturally leads us to our ſecond head.

## OF THE MANAGEMENT OF THE LIGHT.

The pleaſure ariſing from a juſt view of a microſcopic object, the diſtinctneſs of viſion, &c. depend on a due management of the light, and adapting the quantity of it to the nature of the object, and the focus of the magnifier: therefore an object ſhould always be viewed in various degrees of light. For, as Dr. Hooke has well obſerved, it is difficult to diſtinguiſh in ſome objects between a prominency and a depreſſion, between a ſhadow and a black ſtain; and in colour, between a reflection and a whiteneſs: a truth which the reader will find fully exemplified in the examination of the eye of the libella, and other flies, which will be found to appear exceedingly different in one poſition of the light from what they do in another.

The brightneſs of an object depends on the quantity of light; the diſtinctneſs of viſion, on regulating the quantity to the object; for ſome will be loſt, and drowned, as it were, in a quantity of light that is ſcarce ſufficient to render another viſible. A ſtrong light may be thrown on an object various ways; firſt, by means of the ſun and a convex lens; for this purpoſe, place the microſcope about three feet from a ſouthern window; take a deep convex lens, that is mounted in a ſemicircle and fixed on a ſtand, ſo that it's poſition may be eaſily varied; place this lens between the object and the window, ſo that it may collect a conſiderable number of the ſolar rays, and refract them on the object, or the mirror of the microſcope. If the light thus collected from the ſun is too powerful, it may be tempered, by placing a piece of oiled paper, or a glaſs lightly greyed, between the object and the lens: by this means, a convenient degree of light may be obtained, and diffuſed in an equal manner over the whole ſurface of an object, a circumſtance that ſhould be particularly attended to; for if the light be thrown in an irregular manner, that is, larger portions of it on ſome parts than on others, it will not be diſtinctly exhibited.

Where the ſolar light is preferred, it will be found very convenient to darken the room, and to reflect the rays of the ſun on the above-mentioned lens, by means of the mirror of a ſolar microſcope fitted to the window-ſhutter; for by this apparatus the obſerver will be enabled to preſerve the light on his object, notwithſtanding the motion of the ſun.

Cutting off the adventitious light as much as poſſible, by darkening the room where you are uſing the microſcope, and admitting the light only through a hole in the window-ſhutter, or at moſt keeping one window only open, will alſo be found very conducive towards producing a diſtinct view of the object.

As the motion of the ſun, and the variable ſtate of our atmoſphere, renders ſolar obſervations both tedious and inconvenient, it will be proper for the obſerver to be furniſhed with a large tin lanthorn, made ſomething like the common magic lanthorn, fit to contain one of Argand's lamps.* The lanthorn ſhould have an aperture in the front, that may be moved up and down, and capable of holding a lens; by this a pleaſing uniform denſe light may be eaſily procured. The lamp ſhould move on a rod, that it may be readily elevated or depreſſed. The lanthorn may be uſed for many other purpoſes, as for viewing of pictures, exhibiting microſcopic objects on a ſcreen, &c.

Many tranſparent objects are ſeen beſt in a weak light; among theſe we may place the prepared eyes of flies and animalcula in fluids; the quantity of light from a lamp or candle may be leſſened by removing the microſcope to a greater diſtance from them, or it may be more effectually leſſened by cutting off a part of the cone of rays that fall on the object, either by placing the cone, Fig. E, Plate IX. under the ſtage, or by forming circular apertures of black paper, of different ſizes, and placing either a larger or ſmaller one on the reflecting mirror, as occaſion may require.

There is an oblique ſituation of the mirrors, and conſequently of the light, which is eaſily diſcovered by practice, but for which no general rule can be given, that will exhibit an object more beautifully and more diſtinctly than any other poſition, ſhewing the ſurface, as well as thoſe parts through which the light is tranſmitted.

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* The lamp ſhould not be of the fountain kind, becauſe the rarefaction of the air in the lanthorn will often force the oil over.

A better view of moſt objects is obtained by a candle, or lamp, than by day-light; it is more eaſy to modify the former than the latter, and to throw it on the object with different degrees of denſity. From what has been ſaid, the reader will have obſerved the importance of being able to examine the object in the greateſt variety of poſitions and appearances, which cannot be effected with equal convenience by any microſcope but the improved lucernal.

## OF THE PREPARATION OF OBJECTS FOR THE MICROSCOPE.

In the preparation of objects, no man was more ſucceſsful nor more indefatigable than Swammerdam, in minutely anatomizing, in patient inveſtigation, and in curiouſly exhibiting the minute wonders of creation; he ſtands unrivalled, far exceeding all thoſe that preceded, as well as thoſe which have ſucceeded him. Deeply impreſſed and warmly animated by the amazing ſcenes that he continually diſcovered, his zeal in purſuit of truth was not to be abated by diſappointment, or alarmed by difficulty; and was never contented till he had attained a rational and clear idea of the organization of the object, whoſe ſtructure he wiſhed to explore.

We have only to regret that we are ignorant of the methods he employed. To diſcover theſe, the great Boerhaave examined with a ſcrupulous attention all the letters and manuſcripts of Swammerdam, and has communicated the reſult of his reſearches, which, though but ſmall, may enable us to form ſome idea of this great labourer in the field of ſcience.

For diſſecting of ſmall inſects he had a braſs table, which was made by that excellent artiſt S. Muſſchenbrock; to this table were affixed two braſs arms, moveable at pleaſure to any part of it. The upper portion of theſe arms was conſtructed ſo as to have a ſlow vertical motion, by which means the operator could readily alter their height, as he ſaw moſt convenient to his purpoſe; the office of one of theſe arms was to hold the little bodies, and that of the other to apply the lens or microſcope.

His microſcopes, or lenſes, were of various foci, diameters, and ſizes, from the leaſt to the greateſt, and the beſt that could be procured in regard to the exactneſs of the workmanſhip, and tranſparency of the ſubſtance. His way was, to begin his obſervations with the ſmalleſt magnifiers, and from thence proceed by degrees to the greateſt. By nature and uſe he was ſo incomparably dexterous in the management of theſe inſtruments, that he made every obſervation ſubſervient to the next, and all tend to confirm each other, and complete the deſcription.

His chief art ſeems to have been in conſtructing very fine ſciſſars, and giving them an extreme ſharpneſs: theſe he made uſe of to cut very minute objects, becauſe they diſſected them equally; whereas knives and lancets, let them be ever ſo fine and ſharp, are apt to diſorder delicate ſubſtances, as in going through them, they generally draw after and diſplace ſome of the filaments. His knives, lancets, and ſtyles, were ſo very fine, that he could not ſee to ſharpen them without the aſſiſtance of a magnifying glaſs; but with them he could diſſect the inteſtines of bees with the ſame accuracy and diſtinctneſs that the moſt celebrated anatomiſt does thoſe of large animals. He was particularly dexterous in the management of ſmall glaſs tubes, which were no thicker than a briſtle, and drawn to a very fine point at one end, but thicker at the other. Theſe he made uſe of to ſhew and blow up the ſmalleſt veſſels diſcovered by the microſcope, to trace, diſtinguiſh, ſeparate their courſes and communications, or to inject them with very ſubtil coloured liquors.

He uſed to ſuffocate the inſects in ſpirit of wine, in water, or ſpirit of turpentine, and likewiſe preſerved them for ſome time in theſe liquids; by which means he kept the parts from putrefying, and conſequently collapſing and mixing together; and added to them beſides ſuch ſtrength and firmneſs, as rendered the diſſections more eaſy and agreeable. When he had divided tranſverſly with his fine ſciſſars the little creature he intended to examine, and had carefully noted every thing that appeared without further diſſection, he then proceeded to extract the viſcera in a very cautious and leiſurely manner, with other inſtruments of great fineneſs; firſt taking care to waſh away and ſeparate, with very fine pencils, the fat with which inſects are very plentifully ſupplied, and which always prejudice the internal parts before it can be extracted. This operation is beſt performed upon inſects while in the nympha ſtate.

Sometimes he put into water the delicate viſcera of the inſects he had ſuffocated; and then ſhaking them gently, he procured himſelf an opportunity of examining them, eſpecially the air veſſels, which by this means he could ſeparate from all the other parts whole and entire, to the great admiration of all thoſe who beheld them; as theſe veſſels are not to be diſtinctly ſeen in any other manner, or indeed ſeen at all without damaging them, he often made uſe of water, injected by a ſyringe, to cleanſe thoroughly the internal parts, then blew them up with air and dried them, by which means he rendered them durable, and fit for examination at a proper opportunity. Sometimes he has examined with the greateſt ſucceſs, and made the moſt important diſcoveries, in inſects that he had preſerved in balſam, and kept for years together in that condition. Again, he has frequently made punctures in other inſects with a very fine needle, and after ſqueezing out all their moiſture through the holes made in this manner, he filled them with air, by means of very ſlender glaſs tubes, then dried them in the ſhade, and laſt of all anointed them with oil of ſpike, in which a little roſin had been diſſolved, by which means they retain their proper forms a long time. He had a ſingular ſecret, whereby he could ſo preſerve the nerves of inſects, that they uſed to continue as limber and perſpicuous as ever they had been.

He uſed to make a ſmall puncture or inciſion in the tail of worms, and after having gently and with great patience ſqueezed out all their humours, and great part of their viſcera, he then injected them with wax, ſo as to give and continue to them all the appearance of healthy vigorous living creatures. He diſcovered that the fat of all inſects was perfectly diſſolvible in oil of turpentine; thus he was enabled to ſhew the viſcera plainly; only after this diſſolution he uſed to cleanſe and waſh them well and often in clean water. He frequently ſpent whole days in thus cleanſing a ſingle caterpillar of it's fat, in order to diſcover the true conſtruction of this inſect's heart. His ſingular ſagacity in ſtripping off the ſkin of caterpillars, that were upon the point of ſpinning their cones, deſerves particular notice. This he effected, by letting them drop by their threads into ſcalding water, and ſuddenly withdrawing them; for by this means the epidermis peeled off very eaſily; and when this was done, he put them into diſtilled vinegar and ſpirit of wine, mixed together in equal portions, which, by giving a proper firmneſs to the parts, gave him an opportunity of ſeparating them, with very little trouble, from the exuviæ, or ſkins, without any danger to the parts; ſo that by this contrivance, the nymph could be ſhewn to be wrapped up in the caterpillar, and the butterfly in the nymph. Thoſe who look into the works of Swammerdam, will be abundantly gratified, whether they conſider his immenſe labour and unremitted ardour in theſe purſuits, or his wonderful devotion and piety. On one hand, his genius urged him to examine the miracles of the great Creator in his natural productions; whilſt on the other, the love of that ſame all-perfect Being rooted in his mind, ſtruggled hard to perſuade him that God alone, and not the creatures, were worthy of his reſearches, love, and attention.

M. Lyonet always drowned firſt thoſe inſects he intended to anatomize, as by this means he was enabled to preſerve both the ſoftneſs and tranſparency of the parts. If the inſect, &c. is very ſmall, ex. gr. one-tenth of an inch, or a little more in length, it ſhould be diſſected in water, on a glaſs which is a little concave; if after a few days there is any fear that the inſect will putrefy, it ſhould be placed in weak ſpirit of wine, inſtead of water. In order to fix the little creature, it muſt be ſuffered to dry, and then be faſtened by a piece of ſoft wax; after which it may be again covered with water.

Larger objects require a different proceſs; they ſhould be placed in a ſmall trough of thin wood; the bottom of a common chip box will anſwer very well, by ſurrounding the edge of it with ſoft wax, to keep in the water or ſpirit of wine. The inſect is then to be opened, and if the parts are ſoft like thoſe of a caterpillar, they ſhould be turned back and fixed to the trough by ſmall pins; the pins are to be ſet by a pair of ſmall nippers: the ſkin being ſtretched at the ſame inſtant by another pair of finer forceps, the inſect muſt then be placed in water, and diſſected therein, and after two or three days it ſhould be covered with ſpirits of wine, which ſhould be renewed occaſionally; by this means the ſubject is preſerved in perfection, and it's parts may be gradually unfolded, without any other change being perceived than that the ſoft elaſtic parts become ſtiff and opake, and ſome others loſe their colour.

M. Lyonet uſed the following inſtruments in his curious diſſection of the chenille de ſaule. As ſmall a pair of ſciſſars as could be made, the arms long and fine; a ſmall and ſharp knife, the end brought to a point; a pair of forceps, the ends of which had been ſo adjuſted, that they would eaſily lay hold of a ſpider's thread or a grain of ſand. But the moſt uſeful inſtruments were two fine ſteel needles, fixed in ſmall wooden handles, about 2¾ of an inch in length.

An obſervation of Dr. Hooke's may be very uſeful, if attended to, for fixing objects intended to be deſigned by the microſcope. He found no creature more troubleſome to draw than the ant or piſmire, not being able to get the body quiet in a natural poſture. If, when alive, it's feet were fettered with wax or glue, it would ſo twiſt and twine it's body, that it was impoſſible any way to get a good view of it; if it was killed, the body was ſo ſmall, that the ſhape was often ſpoiled before it could be examined. It is the nature of many minute bodies, when their life is deſtroyed, for the parts to ſhrivel up immediately; this is very obſervable in many ſmall plants, as well as in inſects; the ſurface of theſe ſmall bodies, if porous, being affected by almoſt every change of the air; and this is particularly the caſe with the ant. But if the little creature is dropped in well rectified ſpirit of wine, it is immediately killed; and when taken out, the ſpirit of wine evaporates, leaves the animal dry and in it's natural poſture; or at leaſt ſo conſtituted, that you may eaſily place it with a pin in what poſture you pleaſe.*

Having thus given a general account of the methods uſed by Swammerdam and Lyonet, in their examination and diſſection of inſects, we ſhall proceed to ſhew how to prepare ſeveral of their parts for the microſcope, beginning with the WINGS. Many of theſe are ſo tranſparent and clear, as to require no previous preparation; but the under wings of thoſe that are covered with elytra or cruſtaceous caſes, being conſtantly folded up when at reſt, they muſt be unfolded before they can be examined by the microſcope: for this purpoſe, a conſiderable ſhare of dexterity, and ſome patience is neceſſary; for the natural ſpring of the wings is ſo ſtrong, that they immediately fold themſelves again, except they are carefully prevented.

One of the moſt curious and beautiful wings of this kind is that of the EARWIG, of which we have given a drawing, Plate XIV.

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* Hooke's Micrographia, p. 203.

Fig. 1. When expanded it is a tolerably large wing, yet folds up under a caſe not one-eighth part of it's ſize. It is very difficult to unfold this wing, on account of it's curious texture. They are beſt opened immediately after the inſect is killed. Hold the earwig by the thorax, between the finger and thumb; then with a blunt pointed pin endeavour gently to open it, by ſpreading it over the fore-finger, gradually ſliding at the ſame time the thumb over it. When the wing is fully expanded, ſeparate it from the inſect by a ſharp knife, or a pair of ſciſſars. The wing ſhould be preſſed for ſome time between the thumb and finger before it be removed; it may then be placed between two pieces of paper, and again preſſed for at leaſt an hour: after which, it may be put between the talcs without any danger of folding up again.

The wings of the notonecta, and other water inſects, as well as moſt ſpecies of the grylli, require equal care and delicacy with that of the earwig to diſplay them properly.

The WINGS OF BUTTERFLIES AND MOTHS are covered with very minute ſcales or feathers, that afford a beautiful object for the microſcope; near the thorax, the ſhoulder, the middle of the wing, and the fringes of the wings, they are generally intermixed with hair. The ſcales from one part, alſo, often differ in ſhape from thoſe of another; they may be firſt ſcraped off or looſened from the wing with a knife, and then bruſh them into a piece of paper with a camel's hair pencil; the ſcales may be ſeparated from the hairs with the aſſiſtance of a common magnifying glaſs.

The proboſcis of inſects, as of the gnat, the tabanus, &c. requires much attention, and conſiderable care, to be diſſected properly for the microſcope; and many muſt be prepared before the obſerver decides upon the ſituation and ſhape of the parts; he will often alſo be able to unfold in one ſpecimen ſome parts that he can ſcarce diſcover in another. It is well known that the COLLECTOR OF THE BEE forms a moſt beautiful object; a figure of it is given in Plate XIII. Fig. 3. In it is diſplayed a moſt wonderful mechaniſm, admirably adapted to collect and extract the various ſweets from flowers, &c. To prepare this, it ſhould firſt be carefully waſhed with ſpirit of turpentine, by which means it will be freed from the unctuous and melliferous particles which uſually adhere to it; when dry, it muſt be again waſhed with a camel's hair pencil, to diſengage and bring forward the ſmall hairs which form one part of it's microſcopic beauty.

The caſe which encloſes THE STING OF THE BEE, the waſp, and the hornet, are ſo hard, that it is very difficult to extract them without breaking or otherwiſe injuring them. It will be found, perhaps, the beſt way to ſoak the caſe and the reſt of the apparatus for ſome time in ſpirit of wine or turpentine, then lay it on a piece of clean paper, and with a blunt knife draw out the ſting, holding the ſheath by the nail of the finger, or by any blunt inſtrument; great care is requiſite to preſerve the feelers, which when cleaned add much to the beauty of the object.

The EYES OF THE LIBELLULA and different flies, of the lobſter, &c. are firſt to be cleaned from the blood and other extraneous matter, they ſhould then be ſoaked in water for ſome days, after which you may ſeparate one or two ſkins from the eye, which, if they remain, render it too opake and confuſed;

ſome care is, however, requiſite in this ſeparation, otherwiſe the ſkin may be made too thin, ſo as not to enable you to form an accurate idea of it's organization.

The exuviæ of inſects are in general a very pleaſing object, and require but little preparation. If they are curled or bent up, keep them in a moiſt atmoſphere for a few hours, and they will ſoon become ſo relaxed that you may extend them with eaſe to their natural poſitions. The ſteam of warm water anſwers the purpoſe very well.

The beard of the lepas anitifera is to be ſoaked in clean ſoft water, and frequently bruſhed while wet with a camel's hair pencil; it may then be left to dry: after which it muſt be again bruſhed with a dry pencil, to diſengage and ſeparate the hairs, which are apt to adhere together. A picture of this object is repreſented in Plate XIII. Fig. 1.

To view the MUSCULAR FIBRES, take a very thin piece of dried fleſh, and lay it upon a ſlip of glaſs, and moiſten it with warm water; when this is evaporated, the veſſels will appear plain and more viſible, and by repeated macerations the parts may be further diſengaged.

To examine fat, brains, and other ſimilar ſubſtances, we are adviſed by Dr. Hooke to render the ſurface ſmooth, by preſſing it between two thin plates of flat glaſs; by which the ſubſtance will be made much thinner and more tranſparent; otherwiſe the parts lying thick one upon the other, it appears confuſed and indiſtinct.

Some ſubſtances are, however, ſo organized, that if their peculiar form is altered, the parts we wiſh to diſcover are deſtroyed; ſuch as nerves, tendons, muſcular fibres, pith of wood, &c. many of theſe are beſt to be examined while floating in ſome convenient tranſparent fluid. For inſtance, very few of the fibres of any of the muſcles can be diſcovered when they are viewed in the open air; but if placed in water or oil, great part of their wonderful fabric may be diſcovered. If the thread of a ligament is viewed in this manner, it will be ſeen to conſiſt of an indefinite number of ſmooth round threads lying cloſe together.

Objects of an elaſtic nature ſhould be pulled or ſtretched out while they are under the microſcope, that the texture and nature of thoſe parts, whoſe figure is altered by being thus pulled out, may be more fully diſcovered.

To examine BONES with the microſcope. Theſe ſhould firſt be viewed as opake objects; afterwards, by procuring thin ſections, they ſhould be looked at as if tranſparent. The ſections ſhould be cut in all directions, and be well waſhed and cleaned; a degree of maceration will be uſeful in ſome caſes. Or the bones may be put in a clear fire till they are red hot, and then taken out; by this means the bony cells will appear more conſpicuous and viſible, being freed from extraneous matter.

To examine the PORES OF THE SKIN. Firſt, cut or pare off with a razor as thin a ſlice as poſſible of the upper ſkin; then cut a ſecond from the ſame place; apply the laſt to the microſcope.

THE SCALES OF FISH ſhould be ſoaked in water for a few days, and then be carefully rubbed, to clean them from the ſkin and dirt which may adhere to them.

To procure the ſcales of the eel, which are a great curioſity, and the more ſo as the eel was not known to have any till they were diſcovered by the microſcope. Take a piece of the ſkin of the eel that grows on the ſide, and while it is moiſt ſpread it on a piece of glaſs, that it may dry very ſmooth; when thus dried, the ſurface will appear all over dimpled or pitted by the ſcales, which lie under a ſort of cuticle or thin ſkin; this ſkin may be raiſed with the ſharp point of a penknife, together with the ſcales which will then eaſily ſlip out, and thus you may procure as many as you pleaſe.*

On the lizard, the guana, &c. are two ſkins; one of theſe is very tranſparent, the other is thicker and more opake; by ſeparating theſe we procure two beautiful objects.

THE LEAVES of many trees, and ſome plants, when diſſected, form a very pleaſing object. To diſſect them, take a few of the moſt perfect leaves you can find, and place them in a pan with clean water; let them remain three weeks or a month without changing the water; then take them up, and try if they feel very ſoft, and appear almoſt rotten; if ſo, they are ſufficiently ſoaked. You are then to lay them on a flat board, and holding them by the ſtalk, draw the edge of a knife over the upper ſide of the leaf, which will take off moſt of the ſkin; turn the leaf, and do the

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* Martin's Micrographia Nova, p. 29.

the ſame with the under ſide. When the ſkin is taken off on both ſides, waſh out the pulpy matter, and the fibres will be exhibited in a beautiful manner. By ſlitting the ſtalk you may ſeparate the anatomized leaf into two parts. The ſkins that are peeled from the fibres will alſo make a very good object. The autumn is the beſt ſeaſon for the foregoing operation, as the fibres of the leaves are much ſtronger at that ſeaſon, and leſs liable to break.

Ores and minerals ſhould all be carefully waſhed and bruſhed with a ſmall bruſh, to remove any extraneous matter that may adhere to them. Shells may be ground down on a hone, by which their internal ſtructure will be diſplayed.

TO VIEW THE CIRCULATION AND EXAMINE THE PARTICLES OF THE BLOOD. The principal point the obſerver muſt aim at, in order to view the circulation of the blood, is to procure thoſe ſmall animals or inſects that are moſt tranſparent, that by ſeeing through them he may be enabled to diſcover what paſſes within them. The particular kinds beſt adapted for the purpoſe will be enumerated in the deſcriptive catalogue at the end of this work.

If a ſmall eel is uſed for this purpoſe, it muſt be cleanſed from the ſlime which covers it; after which it may be put either in the fiſh-pan, or a glaſs tube filled with water, and then placed under the microſcope. If the eel is ſmall enough, the circulation may be viewed in the moſt ſatisfactory manner. Leeuvenhoeck has given, in his 112th epiſtle, an accurate deſcription of the blood-veſſels in part of the tail of an eel. The ſame figure may alſo be ſeen in my father's Treatiſe on the Microſcope. The tail of any other ſmall fiſh may be applied in the ſame manner, or tied on a ſlip of flat glaſs, and be thus laid before the microſcope. Flounders, eels, and gudgeons, are to be had almoſt at any time in London.—N. B. By filling the tube with water, when an eel is uſed, it will in a great meaſure prevent the ſlimineſs of the eel from ſoiling the glaſs.

To view the particles of the blood, take a ſmall drop of it when warm, and ſpread it as thin as poſſible upon a flat piece of glaſs. By diluting it a little with warm water, ſome of the larger globules will divide from the ſmaller, and many of them will be ſubdivided into ſmaller ones: or a little drop of blood may be put into a capillary tube of glaſs, and be then preſented before the microſcope. Mr. Baker adviſes the mixing the blood with a little warm milk, which, he ſays, will cauſe the unbroken particles to be very diſtinctly ſeen; but the moſt accurate obſerver of theſe particles was Mr. Hewſon, and he ſays, they have been termed globules with great impropriety, being in reality flat bodies. When we conſider how many ingenious perſons have been employed in examining the blood with the beſt microſcopes, it appears ſurprizing that the figure of the particles ſhould be miſtaken; but the wonder is leſſened when we reflect how many obvious things are overlooked, till our attention is particularly directed towards them; and beſides, the blood in the human ſubject, and in quadrupeds, is ſo full of theſe particles, that it is with great difficulty they can be ſeen ſeparate until the blood is diluted. It was by diſcovering a proper method to effect this that Mr. Hewſon was indebted for his ſucceſs. He diluted the particles with ſerum, in which they would remain undiſſolved, and as he could dilute them to any degree with the ſerum, he could eaſily examine the particles diſtinct from each other; ex. gr. take a ſmall quantity of the ſerum of the human blood, and ſhake a piece of craſſamentum in it, till it is coloured a little with the red particles; then with a ſoft hair pencil ſpread a little of it on a piece of thin glaſs, and place this glaſs under the microſcope, in ſuch a manner as not to be quite horizontal, but rather higher at one end than the other; by which means, the ſerum will flow from the higher to the lower extremity, and as it flows ſome of the particles will be found to ſwim on their flat ſides, and will appear to have a dark ſpot in the middle: others will turn over from one ſide to the other, as they roll down the glaſs.

An apparatus has been deſcribed by ſeveral authors for viewing the circulation of the blood in the meſentery of a frog; by this inſtrument curioſity may be gratified; but it is at the expence of humanity, and that without any probability of extending the bounds of ſcience, or promoting the good of mankind. No rational excuſe can be given for depriving a poor creature of it's life, the greateſt boon that nature can beſtow, or even to put it in pain, but an object of utility; he who does from hence procure benefits for the higher orders of animated beings, may be permitted to exert the power which he poſſeſſes over the inferior orders of life. But he greatly errs, if he thinks theſe powers may be uſed to gratify wanton curioſity, or the ſports of an inordinate fancy.

"———— God, when he charg'd the Jew
T' aſſiſt his foe's down-fallen beaſt to riſe;
And when the buſh-exploring boy, that ſeiz'd
The young, to let the parent bird go free,

Prov'd he not plainly that his meaner works
Are yet his care, and have an int'reſt all—
ALL in the univerſal Father's love?"

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"I would not enter on my liſt of friends
(Tho' grac'd with poliſh'd manners and fine ſenſe,
Yet wanting ſenſibility) the man
Who needleſsly ſets foot upon a worm.
An inadvertent ſtep may cruſh the ſnail
That crawls at ev'ning in the public path;
But he that has humanity, forewarn'd,
Will tread aſide, and let the reptile live."

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"A neceſſary act incurs no blame:
Not ſo when held within their proper bounds,
And guiltleſs of offence, they range the air,
Or take their paſtime in the ſpacious field:—
There they are privileg'd. And he that hunts,
Or harms them there, is guilty of a wrong."

COWPER'S POEMS, vol. 2, b. vi.

OF

## OF ANIMALCULA IN INFUSIONS, &c.

Theſe require little or no preparation. The firſt object is to procure them, the ſecond to render them viſible by the microſcope. A few obſervations, however, may be of uſe. Many drops of water may be examined before any can be found; ſo that if the obſerver be too haſty, he may be eaſily diſappointed, though other parts of the ſame water may be fully peopled by them.

The ſurface of infuſed liquors is generally covered with a thin pelicule, which is eaſily broken, but acquires thickneſs by ſtanding; the greateſt number of animalcula are generally to be found in this ſuperficial film.

In ſome caſes it is neceſſary to dilute the infuſions; but this is always to be done with diſtilled water, and that water ſhould be examined in the microſcope before it is made uſe of: the neglect of this precaution has been a ſource of many errors.

Animalcula are in general better obſerved when the water is a little evaporated, as the eye is not confuſed, nor the attention diverted by a few objects. To ſeparate one or two animalcula from the reſt, place a ſmall drop of water on the glaſs near that of the infuſion; make a ſmall neck, or gutter, between the two drops with a pin, which will join them together; then the inſtant you perceive that an animalculum has traverſed the neck or gutter, and entered the drop, cut off the communication between the two drops.

To procure the eels in paſte, boil a little flour and water, till it comes to the conſiſtence of ſuch a paſte as is uſed by the bookbinders; expoſe it to the air in an open veſſel, and beat it together from time to time, to prevent the ſurface thereof growing hard or mouldy: after a few days it will turn ſour; then, if it be examined with attention, you will find myriads of eels on the ſurface.

To preſerve theſe eels all the year, you muſt keep the ſurface of the paſte moiſt, by putting a little water or freſh paſte from time to time to the other. Mr. Baker adviſes a drop or two of vinegar to be put into the paſte now and then. The continual motion of the eels, while the ſurface is moiſt, will prevent the paſte getting mouldy. Apply them to the microſcope upon a ſlip of flat glaſs, firſt putting on it a drop of water, taken up by the head of a pin, for them to ſwim in.

To make an infuſion of pepper. Bruiſe as much common black pepper as will cover the bottom of an open jar, and lay it thereon about half an inch thick; pour as much ſoft water in the veſſel as will riſe about an inch above the pepper. The pepper and water are then to be well ſhook together; after which they muſt not be ſtirred, but be left expoſed to the air for a few days, when a thin pelicule will be formed on the ſurface of the water, containing millions of animalcula.

The obſerver ſhould be careful not to form a judgment of the nature, the uſe, and the operations of ſmall animalcula, from ideas which he has acquired by conſidering the properties of larger animals: for, by the aſſiſtance of glaſſes, we are introduced as it were into a new world, and become acquainted not only with a few unknown animals, but with numerous ſpecies thereof. which are ſo ſingular in their formation and habits, that without the cleareſt proofs even their exiſtence would not be credited; and while they afford freſh inſtances of the Creator's power, they alſo give further proofs of the limits and weakneſs of the human underſtanding.

## DIRECTIONS FOR FINDING, FEEDING, AND PRESERVING THE POLYPES.

Theſe little animals are to be found upon all ſorts of aquatic plants, upon branches of trees, pieces of board, rotten leaves, ſtones, and other ſubſtances that lie in the water; they are alſo to be found upon the bodies of ſeveral aquatic animals, as on the water-ſnail, on ſeveral ſpecies of the monoculus, &c. they generally fix themſelves to theſe by their tail, ſo that it is a very good method when you are in ſearch of polypes, to take up a great many of theſe ſubſtances, and put them in a glaſs full of water. If there be any polypes adhering to theſe, you will ſoon perceive them ſtretching out their arms, eſpecially if the glaſs is let ſtand ſtill for a while without moving it; for the polypes, which contract themſelves on being firſt taken out of the water, will ſoon extend themſelves again when they are at reſt.

They are to be ſought for in the corners of ditches, puddles, and ponds, being generally driven into theſe with the pieces of wood or leaves to which they have attached themſelves. They may, therefore, be ſought for in vain at one period, in a place where at another you ſhall find them in abundance. They are more eaſily perceived in a ditch when the ſun ſhines on the bottom, than at another time. They are ſeldom to be met with in winter: about the month of May they begin to appear and increaſe.

They are generally to be found in waters which move gently; for neither a rapid ſtream, nor ſtagnant waters, ever abound with them. As they are always fixed to ſome ſubſtance by their tails, and are very rarely looſe in the water, taking up water only can ſignify but little: a circumſtance which has probably been the cauſe of much diſappointment to thoſe who have ſearched for them.

The green polypes are generally about half an inch long when ſtretched out; thoſe of the ſecond and third ſort are between three quarters of an inch and an inch in length; though ſome are to be found at times which are an inch and a half long.

Heat and cold has the ſame effect upon theſe little creatures, that it has upon thoſe of a larger ſize. They are animated and enlivened by heat, whereas cold renders them faint and languid; they ſhould therefore be kept in ſuch a degree of heat, that the water may not be below temperate.

It is convenient for many experiments to ſuſpend a polype from the ſurface of the water. To effect this, take a hair pencil in one hand, and hold a pointed quill in the other; with the pencil looſen the polype from the receiver in which it is kept, and gradually raiſe it near the top of the water, ſo that the anterior end may be next the point of the pencil; then lift it out of the water, and keep it ſo for a minute; after which, thruſt the point of the pencil, together with the anterior end, by little and little under water, until no more than about half the tenth of an inch of the polype's tail remains above it's ſurface; at this inſtant, with the pointed quill remove that part of the polype from the pencil which is already in the water, and at the ſame time blowing againſt the polype, it will be looſened, and remain out of the water.

When the polypes were firſt diſcovered, Mr. Trembley had ſome difficulty to find out that food which was proper for them; but he ſoon diſcovered, that a ſmall ſpecies of the millepede anſwered the purpoſe very well: the pulices aquatices have alſo been recommended. The ſmall red worms, which are to be found on the mud-banks of the Thames, particularly near the ſhores, anſwer the purpoſe alſo; they are eaſily found when the tide is out, when they riſe in ſuch ſwarms on the ſurface of the mud, that it appears of a red colour. Theſe worms are an excellent food for the polype. If a ſufficient quantity is gathered in November, and put into a large glaſs full of water, with three or four inches of earth at the bottom, you will have a ſupply for the polypes all the winter. They may alſo be fed with common worms, with the larva of gnats and other inſects, and even with butchers meat, &c. if it be cut ſmall enough.

River, or any ſoft water, agrees with them; but that which is hard and ſharp prevents their thriving, and generally kills them in a few days. The worms with which they are fed ſhould be always cleanſed before you feed the polypes with them.

The polypes are commonly infeſted with little lice; from theſe it is neceſſary to free them, in order to preſerve your polypes in a good ſtate of health. They may be cleanſed from the lice by rubbing them with a hair pencil; this cannot be eaſily done, without they have affixed themſelves to ſome ſubſtance: ſo that if they are ſuſpended from the ſurface of the water, you muſt endeavour to get them to fix themſelves to a piece of packthread; when they are faſtened thereto, you may then rub them with a hair pencil, without looſening them from the thread.

The lice which torment the polype are not only very numerous, but they are alſo very large relative to it's ſize: they may be ſaid to be nearly as large with reſpect to them, as a common beetle is to us. If they are not rubbed off, they ſoon cover their bodies, and in a little time totally deſtroy them.

To preſerve the polypes in health, it is alſo neceſſary often to change the water they are kept in, and particularly after they have done eating; it is not ſufficient to pour the water off, all the polypes ſhould be taken out, and the bottom and ſides of the veſſel rubbed from the ſlimy ſediment adhering thereto; this is cauſed by their fæces, and is fatal to them if not cleaned away. The fæces often occaſion a ſpecies of mortification, which increaſes every day; it's progreſs may be ſtopped by cutting off the diſeaſed part. To take them out, firſt looſen their tails from the ſides or bottom of the glaſs; then take them up one by one, with a quill cut in the ſhape of a ſcoop, and place them in another glaſs with clean water; if they cling to the quill, let it remain a minute or two in water, and they will ſoon diſengage themſelves.

They are preſerved beſt in large glaſſes, that hold three or four quarts of water; for in a glaſs of this ſize the water need not be renewed ſo often, particularly if the fæces are taken out from time to time with the feathered end of a pen, to which it readily adheres; and further, the trouble of feeding each individual is in ſome meaſure ſaved, as you need only throw in a parcel of worms, and let the polypes divide them for themſelves.

To obſerve with accuracy the various habitudes, poſitions, &c. of this little animal, it will be neceſſary to place ſome of them in narrow cylindrical glaſſes; then, by means of the microſcope, Fig. 3, Plate VI. you may obſerve it exerting all it's actions of life with eaſe and convenience; the facility with which the lens of the fore-mentioned microſcope may be moved and placed in any direction, renders it a moſt convenient inſtrument for examining any object that requires to be viewed in water.

It is alſo very proper to dry ſome of them, and place them between talcs in a ſlider; this however requires ſome dexterity, and a little practice; tho' when executed with ſucceſs, it fully rewards the pains of the obſerver. Chuſe a proper polype, and put it in a ſmall concave lens, with a drop of water; when it is extended, and the tail fixed, pour off a little of the water, and then plunge it with the concave into ſome ſpirit of wine contained in the bowl of a large ſpoon; by this it is inſtantly killed, the arms and body contracting more or leſs; rub it gently, while in ſpirits, with a ſmall hair pencil, to cleanſe it from the lice.

The difficulty now begins; for the parts of the polype, on being taken out of the ſpirits, immediately cling together, ſo that it is not practicable to extend the body, and ſeparate the arms on the talc, without tearing them to pieces: ſo that the only method is, to adjuſt them upon the talc while in the ſpirits; this may be done by ſlipping the talc under the body of the polype, while it lies in the ſpirits, and diſplaying it's arms thereon by the ſmall hair pencil and a pair of nippers; then lift the talc, with the polype upon it, out of the ſpirits; take hold of it with the nippers in the left hand, dip the pencil in the ſpirits with the right hand, and therewith diſpoſe of the ſeveral parts, that they may lie in a convenient manner, at the ſame time bruſhing away any lice that may be ſeen upon the talc; now let it dry, which it does in a little time, and place the talc carefully in the hole of the ſlider. To prevent the upper talc and ring preſſing on the polype, you muſt cut three pieces of cork, about the bigneſs of a pin's head, and the depth of the polype, and fix them by gum in a triangular poſition, partly on the edges of the ſaid talc, partly to the ſides of the ivory hole itſelf; the upper talc may then be laid on theſe corks, and preſſed down by the ring as uſual.*

## OF VEGETABLES.

I wiſh I could give the reader a ſatisfactory account of all the preparations which are requiſite to fit for the microſcope the objects of the vegetable kingdom. Dr. Hill is the only writer who has handled this ſubject. I ſhall, therefore, extract from his "Treatiſe on the Conſtruction of Timber," what he has ſaid; this, together with the improvements I have made on the cutting engine, will enable the reader to purſue the ſubject, and extend it further, both for his own pleaſure, and the advantage of the public.

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* Baker on the Polypes.

## THE MANNER OF OBTAINING THE PARTS OF A SHOOT SEPARATE.

In the beginning of April, take a quantity of young branches from the ſcarlet oak, and other trees. Theſe are firſt cut into lengths, of the growth of different ſeaſons; and then part are left entire, part ſplit, and the reſt quartered. In this ſtate they are put into a wicker baſket, with large openings, or of looſe work, and a heavy ſtone is put in with them: a rope is tied to the handle of the baſket, and it is thrown into a brook of running water: at times it is taken up, and expoſed a little to the air; it is frequently ſhook about under water, to waſh off filth; and once in ten days the ſticks are examined.

By degrees the parts looſen from one another; and by gentle rubbing in a baſon of water, juſt warmed, they will be ſo far ſeparated, that a pencil bruſh will perfect the buſineſs, and afford pieces of various ſize, pure, diſtinct, and clean. One part will in this way ſeparate at one time, and another at another; but by returning the ſticks to the water, and repeating the operation, in the courſe of four or five weeks, every part may be obtained diſtinct. They are beſt examined immediately; but if any one wiſhes to preſerve them for repeated inquiries, it may be done in this manner: diſſolve half an ounce of alum in two quarts of water; drop the pieces thus ſeparated, for a few moments, into this ſolution, then dry them upon paper, and put them up in vials of ſpirit of wine. Nothing but ſpirit of wine can preſerve theſe tender bodies.

## TO PREPARE THE RIND FOR OBSERVATION.

As the veſſels of the rind are of different diameters in various trees, though their conſtruction and that of the blebs is perfectly the ſame in all, it will be beſt to chuſe for this purpoſe the rind of a tree wherein they are largeſt. The rind of the aſh-leaved maple is finely ſuited. A piece of this may be obtained of two inches long, and will very ſucceſsfully anſwer the intention. Such a piece being prepared without alum or ſpirit, but dried from the water in which it had been macerated, it is to be impregnated with lead in the following manner, to ſhew the apertures by their colour.

Diſſolve one dram of ſugar of lead in an ounce and a half of water; filter this through paper, and pour it into a tea-cup. Clip off a thin ſlice of what was the lower end of the piece of rind as it grew on the tree, and plunge it near an inch deep into the liquor; keep it upright between two pieces of ſtick, ſo that one half or more may be above the water: whelm a wine and water glaſs over the tea-cup, and ſet the whole in a warm place. When it has ſtood two days, take it out, and clip off all that part which was in the liquor, and throw it away.

The circumſtances here mentioned, trivial as they ſeem, muſt be attended to: the operation will not ſucceed, even if the covering-glaſs be omitted; it keeps a moiſt atmoſphere about the rind, and makes it's veſſels ſupple.

While this is ſtanding, put into a baſon two ounces of quick lime, and an ounce of orpiment; pour upon them a pint and a half of boiling water; ſtir the whole together, and when it has ſtood a day and night, it will be fit for uſe. This is the liquor probatorius vini of ſome of the German chemiſts : it diſcovers lead when wines are adulterated with it, and will ſhew it any where.

Put a little of this liquor in a tea-cup, and plunge the piece of rind half-way into it.

In the former part of this experiment, the veſſels of the rind have been filled with a ſolution of lead, that makes of itſelf no viſible alteration in them ; but this colourleſs impregnation, when the orpiment lixivium gets to it, becomes of a deep brown; the veſſels themſelves appear ſomewhat the darker for it; but theſe dots, which are real openings, now are ſeen to be plainly ſuch, the colour being perfectly viſible in them, and much darker than in the veſſels. This object muſt be always viewed dry.

If a piece of the rind, thus impregnated, be gently rubbed between the fingers, till the parts are ſeparated, we ſhall be able in one place or other to get a view of the veſſels all round, and of the films which form the blebs between them.

Every part of the rind, and every coat of it, even the interſtitial place between it's innermoſt coat and bark, are filled with a fine fluid. The very courſe and progreſs of the fluid may be ſhewn in this part, even by an eaſy preparation: only that different rinds muſt be ſought for this purpoſe, the veſſels in ſome being larger than in others. Repeated trials have ſhewn me that the whole progreſs may be eaſily marked in the three following kinds, with only a tincture of cochineal.

Put half an ounce of cochineal, in powder, into half a pint of ſpirit of wine; ſet it in a warm place, and ſhake it often for four days; then filter off the clear tincture. Put an inch depth of this into a cup, and ſet upright in it pieces of the rind of aſh, white willow, and ozier, prepared as has been directed, by maceration in water; for in that way one trouble does for a hundred kinds. Let an inch of the rinds alſo ſtand up out of the tincture. After twenty-four hours take them out, clip off the part which was immerſed in the fluid, and ſave the reſt for obſervation.

## TO PREPARE THE BLEA.

Cut the pieces in a fit ſeaſon, either juſt before the firſt leaves of ſpring, or in the midſummer ſhooting time. Then we ſee all the wonders of the ſtructure; the thouſands of mouths which open throughout the courſe of theſe innumerable veſſels, to pour their fluid into the interſtitial matter.

Theſe veſſels, which are in nature ciſterns of ſap for the feeding the growth of the whole tree, are ſo large, that they are capable of being filled with coloured wax, in the manner of the veſſels in anatomical injections; and this way they afford pleaſing objects for the microſcope, and give excellent opportunities of tracing their courſe and ſtructure.

## A METHOD OF FILLING THE SAP VESSELS OF PLANTS.

A great many ſhoots of the ſcarlet and other oaks are to be taken off in the ſpring; they muſt be cut into pieces of about two inches in length, and immediately from the cutting they muſt drop into ſome warm rain water: in this they are to ſtand twenty-four hours, and then be boiled a little. When taken out, they are to be tied on ſtrings, and hung up in a place where the air paſſes freely, but the ſun does not ſhine. When they are perfectly dry, a large quantity of green wax, ſuch as is uſed for the ſeals of law deeds, is to be gently melted in an earthen pipkin ſet in water; the water to be heated and kept boiling. As ſoon as the wax runs, the ſticks are to be put in, and they are frequently to be ſtirred about. They muſt be kept in this ſtate about an hour, and then the pipkin is to be taken out of the water, and ſet upon a naked fire, where it is to be kept with the wax boiling for two or three hours; freſh ſupplies of the ſame wax being added from time to time.

After this it is to be removed from the fire, and the ſticks immediately taken out with a pair of nippers; when they are cold, the rough wax about them is to be broken off. Both ends of each ſtick are to be cut off half an inch long, and thrown away, and the middle pieces ſaved. Theſe are then to be cut in ſmaller lengths, ſmoothed at the ends with a fine chiſſel, and many of them ſplit in various thickneſſes.

Thus are obtained preparations, not only of great uſe, but of a wonderful beauty. Many trees this way afford handſome objects as well as the oak; and in ſome, where the ſap veſſels are few, large, and diſtinct, the ſplit pieces reſemble ſtriped ſatins, in a way ſcarce to be credited. It is in ſuch that the outer coats of theſe veſſels are moſt happily of all to be examined.

## THE METHOD OF PREPARING SALTS AND SALINE SUBSTANCES FOR THE VIEWING THEIR CONFIGURATIONS.

Diſſolve the ſubject to be examined in no larger a quantity of river or rain water than is ſufficient to ſaturate it; if it is a body eaſily diſſolvable, make uſe of cold water, otherwiſe make the water warm or hot, or even boiling, according as you find it neceſſary. After it is perfectly diſſolved, let it reſt for ſome hours, till, if over-charged, the redundant ſaline particles are precipitated, and ſettle at the bottom, or ſhoot into cryſtals; by which means you are moſt likely to have a ſolution of the ſame ſtrength at one time as at another; that is, a ſolution fully charged with as much as it can hold up, and no more: and by theſe precautions the configurations appear alike, how often ſoever tried: whereas, if the water be leſs ſaturated, the proportions, at different times, will be ſubject to more uncertainty; and if it be examined before ſuch ſeparation and precipitation of the redundant ſalts, little more will be ſeen than a confuſed maſs of cryſtals.

The ſolution being thus prepared, take up a drop of it with a gooſe quill, cut in faſhion of a ſcoop, and place it on a flat ſlip of glaſs, of about three quarters of an inch in width, and between three and four inches long, ſpreading it on the glaſs with the quill, in either a round or oval figure, till it appears a quarter of an inch or more in diameter, and ſo ſhallow as to riſe very little above the ſurface of the glaſs. When it is ſo diſpoſed, hold it as level as you can over the clear part of a fire that is not too fierce, or over the flame of a candle, at a diſtance proportionable to the degree of heat it requires, (which experience only can direct) and watch it very carefully till you diſcover the ſaline particles beginning to gather and look white, or of ſome other colour, at the extremities of the edges; then having adjuſted the microſcope before-hand for it's reception, armed with the fourth glaſs, which is the fitteſt for moſt of theſe experiments, place it under your eye, and bring it exactly to the focus of the magnifier; and after running over the whole drop, fix your attention on that ſide where you obſerve any increaſe or puſhing forwards of cryſtalline matter from the circumference towards the center.

This motion is extremely ſlow at the beginning, unleſs the drop has been over-heated, but quickens as the water evaporates, and in many kinds, towards the concluſion, produces configurations with a ſwiftneſs inconceivable, compoſed of an infinity of parts, which are adjuſted to each other with an elegance, regularity, and order, beyond what the exacteſt pencil in the world, guided by the ruler and compaſs, can ever equal, or the moſt luxuriant imagination fancy.

When action once begins, the eye cannot be taken off, even for a moment, without loſing ſomething worth obſervation; for the figures alter every inſtant, till the whole proceſs is over; and in many ſorts, after all ſeems at an end, new forms ariſe, different entirely from any that appeared before, and which probably are owing to ſome ſmall quantity of ſalt of another kind, which the other ſeparates from, and leaves to act, after itſelf has done; and in ſome ſubjects three or four different ſorts are obſervable, few or none being ſimple and homogeneous.

When the configurations are fully formed, and all the water evaporated, moſt kinds of them are ſoon deſtroyed again by the moiſture or action of the air upon them; their points and angles loſe their ſharpneſs, become uneven and defaced, and moulder as it were away; but ſome few are permanent, and by being incloſed between glaſſes, they may be preſerved months or even years.

It happens oftentimes that a drop of a ſaline ſolution can hardly be ſpread on the ſlip of glaſs, by reaſon of the glaſs's ſmoothneſs, but breaks into little globules, as it would do were the ſurface greaſy: the way to prevent this is, by rubbing the broken drop with your finger over the glaſs, ſo as to leave the glaſs ſmeared with it; on which ſmeared place, when dry, another drop of the ſolution may be ſpread very eaſily in what form one pleaſes.

It ſometimes happens, that when a heated drop is placed properly for examination, the obſerver finds he can diſtinguiſh nothing; which is owing to ſaline ſteams that riſe from the drop cover, and obſcure the object glaſs, and therefore muſt immediately be wiped away with a ſoft cloth or leather.

In all examinations by the microſcope of ſaline ſolutions, even though made in the day-time, you muſt uſe a candle; for the configurations being exceedingly tranſparent, are rendered much more diſtinguiſhable by the brown light a candle affords, than by the more white and tranſparent day-light; and beſides, either by moving the candle or turning the microſcope, ſuch light may be varied or directed juſt as the ſubject requires.

It may be alſo proper to take notice, that no kinds of microſcopes are fit for theſe obſervations, but ſuch as have an open ſtage, whereon the ſlips of glaſs, with the liquor upon them, may be placed readily, and in a perfect horizontal poſition; and moreover, where they can be turned about freely, and without diſordering the fluid.

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# CHAP. V.

## OF INSECTS IN GENERAL.

NATURAL hiſtory has been more cultivated in the preſent century than in all thoſe which have preceded it. Many men, of the firſt rank in literature, have not diſdained to become labourers in the vaſt field which this ſcience offers every day to the eyes of an accurate and attentive obſerver. The animal, the vegetable, and the mineral kingdoms, have been examined with the greateſt care; and that confuſion and perplexity, which, from a view of the immenſe variety of individuals which each kingdom contained, it ſeemed natural to apprehend, has been removed, by introducing ſyſtematic order into this branch of ſcience; by which means the various individuals have been diſtributed into claſſes and genera, and we are now enabled to form diſtinct and accurate ideas of them. To the ſame ſyſtematic plan, and the nicety of diſcrimination which ariſes from it, we are indebted for the diſcovery and deſcription of many new ſpecies in each kingdom.

Amidſt the numerous objects which crowd in upon the natural hiſtorian, and engage his attention, inſects have not been neglected; and though they are the moſt numerous of the animal tribe, and for the moſt part very ſmall, yet the knowledge of their nature and wonderful œconomy has been cultivated with unremitting ardour. Some authors have confined themſelves to divide and ſeparate them into various claſſes, and deſcribe their characteriſtic differences: others have been employed in tracing their habits of life, or in exploring the wonderous mechaniſm of their frame and ſtructure; ſo that the nature, habits, and many peculiarities of their ſtate of life, are now well known.

In number, ſingularity of appearance, and variety of form, inſects exceed every other part of animated nature. Earth, air, and water, are filled with hoſts thereof, a far greater part of which are inviſible to the naked eye; but amongſt all this variety, we perceive the ſame regularity, and can trace the footſteps of that love and wiſdom which ſo ſtrongly marks every work of God. In contemplating the works of the Creator, we ſhall always find his wiſdom and his love in pages written by his own eternal hand, in characters legible to every eye.

After an attentive examination of the nature and fabric of both the leaſt and largeſt animals, I cannot (ſays the truly great and moſt excellent Swammerdam) but allow the leſs an equal, perhaps a ſuperior, degree of dignity. Whoever duly conſiders the conduct and inſtinct of the one, with the manners and actions of the other, muſt acknowledge all are under the direction and controul of a ſupreme and particular intelligence; which, as in the largeſt it extends beyond the limits of our comprehenſion, eſcapes our reſearches in the ſmalleſt. If, while we diſſect with care the larger animals, we are filled with wonder at the elegant diſpoſition of their limbs, the inimitable order of their muſcles, and the regular direction of their veins, arteries, and nerves; to what an height is our aſtoniſhment raiſed, when we diſcover all theſe parts arranged in the leaſt, in the ſame regular manner. How is it poſſible but what we muſt ſtand amazed, when we reflect that thoſe little animals, whoſe bodies are ſmaller than the point of the diſſecting knife, have muſcles, veins, arteries, and every other part common to the larger animals? Creatures ſo very diminutive, that our hands are not delicate enough to manage, nor our eyes ſufficiently acute to ſee them.

All beings are perfect, conſidered in themſelves: they all anſwer one end. The determinations or qualities of each being are the means relative to this end. Thoſe means which are of an exalted nature anſwer a nobler or higher purpoſe. The meaſure of perfection conſiſts in the relation which every being bears to the whole.

When conſidered with reſpect to the Creator, all creatures are upon a level; and yet, as creatures, even the moſt deſpicable bear ſuch relation to their Creator, as to make them highly valuable to their fellow-creatures, who are themſelves only valuable by ſharing and partaking of the Divine influence. As the harmony and infinity of the eternal Artiſt are impreſſed on all his works, and as outwardly we can find no bounds, ſo inwardly we can find no end of art and beauty. "Let us then not ſlight or deem that little, in which immenſity is ſo conſpicuous; or that trivial, in which there is ſuch a manifeſtation of infinite wiſdom and power:"* but let us rather

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* Brooke's Univerſal Beauty, a poem.

———" Muſe upon his ſkill diſplayed;
(Infinite ſkill) in all that he has made!
To trace in nature's moſt minute deſign,
The ſignature and ſtamp of pow'r divine;
Contrivance intricate, expreſs'd with eaſe,
Where unaſſiſted ſight no beauty ſees;
The ſhapely limb, and lubricated joint,
Within the ſmall dimenſions of a point;
Muſcle and nerve miraculouſly ſpun,
His mighty work, who ſpeaks and it is done,
Th' inviſible in things ſcarce ſeen reveal'd,
To whom an atom is an ample field.
To wonder at a thouſand inſect forms,
Theſe hatch'd, and thoſe reſuſcitated worms,
New life ordain'd, and brighter ſcenes to ſhare,
Once prone on earth, now buoyant upon air."*

The name of inſect has been appropriated to theſe ſmall animals on account of the ſections or diviſions in the bodies of the greater number of them, from whence the parts ſeem to be joined together by a kind of neck. It is perhaps impoſſible to find any general term that ſhall embrace the whole genera of inſects, as many circumſtances muſt be deſcribed before we can attain an exact notion of theſe animals and their conſtitution.

Inſects are by moſt writers conſidered as divided into four principal parts; the caput or head, the thorax or trunk, the abdomen or belly, and artus or limbs: a perfect knowledge of theſe parts, and their ſeveral ſubdiviſions, is requiſite for thoſe who are deſirous of forming accurate ideas of theſe little animals, or who wiſh to arrange them in their proper claſſes.

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* Cowper's Poems, vol. I. p. 261.

THE HEAD is affixed to the thorax by a ſpecies of articulation or joint; it is the principal ſeat of the ſenſes, and contains the rudiments of the brain;* it is furniſhed with a mouth, eyes, antennæ, a forehead, a throat, and ſtemmata. In the greater part of inſects the head is diſtinctly divided from the thorax, but in others it coaleſces with it. The head of ſome inſects is very large in proportion to their bodies; the proportion between the head of the ſame inſect is not always the ſame; in the caterpillars with horny heads it is generally ſmall before they moult or change their ſkin, but much larger after each moulting. The hardneſs of the exterior part of the head prevents it's growth before the change, it is conſequently, relative to the body, very ſmall; but when the inſect is diſpoſing itſelf for the change, the internal ſubſtance of the head retires inwards to the firſt ring of the neck, where it has room to expand itſelf; ſo that when the animal quits the ſkin, we are ſurpriſed with a head twice the former ſize: and as the inſect neither eats nor grows while the head is forming, there is this further circumſtance to be remarked, that the body and the head have each their particular time of growth. While the head expands and grows, the body does not grow at all; when the body increaſes, the head remains of the ſame ſize, without any change. The heads of all kinds of inſects form very pleaſing as well as moſt diverſified objects for the opake microſcope.

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* Fabricius Philoſophia Entomologica, p. 18.

THE MOUTH is a part of the inſect to which the naturaliſt will find it neceſſary to pay a very particular attention: Fabricius goes ſo far as to aſſert, that without a thorough knowledge of the mouth, it's form, and various appendages, it will be impoſſible ever to diſcriminate with accuracy one inſect from another. In the ſtructure of the mouth conſiderable art and wiſdom is diſplayed: the diverſity in the figure is almoſt as great as the variety of ſpecies. It is uſually placed in the fore part of the head, extending ſomewhat downwards; in the chermes, coccus, and ſome other inſects, it is placed under the breaſt. Some inſects have their mouths armed with ſtrong jaws, with which they bruiſe and tear their food: however fine and delicate theſe organs may appear, they are really hard, and in ſome ſpecies ſufficiently ſtrong to pierce the hardeſt wood. Others are furniſhed with a kind of tube or tongue, at one time moveable, at another fixed: with this they ſuck the juices of the flowers. In ſome again the tongue is ſo ſhort as to appear to us incapable of anſwering the purpoſe for which it was formed, and the oeſtri appear to have no mouth.

The roſtrum, or proboſcis, is the mouth drawn out to a rigid point. In many inſects of the hemiptera claſs it is bent downward towards the breaſt and belly.

The jaws are generally two in number, ſometimes four, and at others more; they are placed in an horizontal direction: the inner edge, in ſome inſects, is ſerrated, or furniſhed with ſmall teeth.

The tongue is in general a taper and compact inſtrument, uſed by the inſect to extract the alimentary juices on which it feeds:

ſome can extend or contract it; others roll up their's with dexterity; in ſome it is incloſed in a ſheath, with the pointed end of which they pierce the ſubſtances which contain their food, and then extract the juice with their tongue; in many it is placed in a groove under the belly; taper and ſpiral in the butterfly; tubular and fleſhy in the fly; in ſome it is long, and in others ſhort, but in all affording a fund of amuſement for the microſcope.

M. De Geer * has given us an account of a very curious circumſtance concerning the tongue of the papillon de ſaules. † Having cut off the tongue from the butterfly, almoſt as ſoon as it was emancipated from the chryſalis, it moved and rolled itſelf up at intervals for a conſiderable time: an hour after it had been cut off, it repeated the ſame motions, recommencing them every time it was touched. The ſame effect does not follow if the butterfly has been freed from the chryſalis a few days.

The ſtructure of THE EYE is, in all creatures, a moſt admirable piece of mechaniſm, but in none more ſo than in thoſe of inſects: there is no part of theſe ſmall creatures which exhibits more clearly the prodigious art with which they are organized, and ſhews how many wonders eſcape the natural ſight of man. The eyes are very different in different ſpecies, varying in number, ſituation, connection, figure, and ſimplicity of conſtruction. The greater part have two eyes, but in the monoculus they approach ſo near to each other as to appear like one; the gyrinus has four eyes, the ſcorpion ſix, the ſpider eight, and the ſcolopendra three.
The

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* De Geer, Memoires pour ſervir à L'Hiſtoire des Inſectes, tom. I. p. 77.

† Papilio Antiopa, Lin. Syſt. Nat. p. 776, N° 165.

The eyes are generally convex; they have no eye-brows, the outer tunic is hard and tranſparent, having no external motion, the genus of canceri or crabs excepted. The eyes of the greater number appear, when examined by the microſcope, to be cut into a multitude of little planes or facets, like the facets of a diamond, having to the naked eye the appearance of net-work. Each of theſe ſmall facets is ſuppoſed to poſſeſs the powers and properties of an eye. Leeuenhoek counted 3181 of theſe facets in the cornea of a beetle, 8000 in thoſe of a fly. As the eyes of inſects are immoveable, they would have loſt ſight of many objects, if their eyes had been framed like thoſe of other animals; but by means of their multiplied eyes, they can eaſily view ſurrounding objects: nor is it at all improbable, that, as objects do not appear double to our eyes, but that they are ſtrengthened, and many falſe appearances are corrected by the uſe of both; ſo the numerous inlets to ſight in an inſect may increaſe their field of view, augment the intenſity of the light, and be productive of other advantages, of which we can form no conception. The eyes of inſects differ in colour, ſome being found of every colour, and of inexpreſſible beauty and brightneſs.

The antennæ are fine and ſlender horns, conſiſting of ſeveral articulations, moveable in various directions. They are beautiful in form, of a delicate ſtructure, and are placed in the fore part of the head: they vary in different inſects, not only in their ſhape, their length, their bulk, but alſo in the number of their articulations. The antennæ of the male inſect generally differ from thoſe of the female: they form one of the moſt diſtinguiſhing characteriſtics of inſects, and one of the means of judging to what genus they belong. The greateſt number of inſects have only two antennæ; the oniſcus, the pagurus, and aſtacus have four; indeed Fabricius gives ſix to the latter.* Of the uſe they are to theſe little animals, or the end of the Creator in forming them, we are altogether ignorant: ſome writers have conjectured that they were the organs of ſmell and hearing; others have ſuppoſed that they were appropriated to a feeling more delicate than our own, and ſenſible to the leaſt motion or diſturbance in the ambient fluid in which they move: ſeveral inſects cover their eyes with them when they take their reſt. They are characterized by naturaliſts under the following names:

SETACEOUS are thoſe that, like a briſtle, grow gradually taper towards their point or extremity.

FILIFORM, thread ſhaped, and of an uniform thickneſs.

MONILIFORM; theſe are of a regular thickneſs, but conſiſt of a ſeries of knobs, like a necklace of beads.

CLAVATED, formed like a club, increaſing gradually from the baſe to the extremity.

CAPITATED; theſe are alſo formed like a club, but the laſt articulation is larger than the reſt, finiſhing with a kind of capital or head.

FISSILES; theſe are like the former, only that the head is divided into different parts or laminæ.

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* Fabricius Philoſophia Entomologica, p. 19.

PERFOLIATÆ; in theſe the head is divided horizontally, but the laminæ are connected by a kind of thread paſſing through their center.

PECTINATÆ; theſe have ſeveral lateral appendages, and appear like a feather.

ARISTATÆ, ſuch as have a lateral hair, which is either naked, or furniſhed with ſmaller hairs.

Beſides the foregoing terms, the antennæ are called ſhort (*breviores*) when they are ſhorter than the body; *mediocres*, or middling, when they are of the ſame length; and *longiores*, when they are longer.

Near the mouth there is alſo a ſpecies of ſmall filiform articulated antennæ, called the PALPI, or feelers; they are generally four in number, ſometimes ſix; they are placed under and at the ſides of the mouth, which ſituation, together with their ſize, ſufficiently diſtinguiſh them from the antennæ; they are in continual motion, the animal thruſting them in every matter, as a hog would it's noſe, when in ſearch of food. Some have ſuppoſed them to be a kind of hand to aſſiſt in holding the food when it is near the mouth.

THE FOREHEAD occupies the upper part of the head, between the eyes, the mouth, and the thorax.

THE STEMMATA, or crown, three elevated ſhining hemiſpheric ſpots reſembling eyes, and placed upon the upper part of the head, as in moſt of the hymenoptera claſs.

The trunk is ſituated between the head and the abdomen; the legs and wings are inſerted into it; but in order to diſtinguiſh the parts thereof more eaſily, it is divided into the thorax, ſcutellum, and ſternum.

The thorax is the upper part of the trunk; it is of various ſhapes and proportions; the ſides and back of it are often armed with points.

The scutellum, or eſcutcheon, is the poſterior part of the thorax, and is generally of a triangular form; though it adheres to the thorax, yet it is eaſily diſtinguiſhed from it, by it's figure, it's uſe, and often by an intervening ſuture; it appears deſigned to aſſiſt in expanding the wings when the inſect is going to fly.

The sternum is ſituated on the inferior part of the thorax; it is pointed behind in ſome ſpecies, and bifid in others.

The abdomen contains the ſtomach, the inteſtines, the air veſſels, the ovary, &c. it is affixed to the thorax, and in moſt inſects diſtinct from it, forming the poſterior part of the body, being generally compoſed of rings or ſegments, by which the inſect can lengthen or ſhorten it, or even move it in different directions. In ſome ſpecies it ſeems to be formed but of one piece. The upper part of the abdomen is called the tergum, the under part the venter; the anus is the poſterior part of the abdomen.

The spiracula are ſmall oblong oval holes or pores, that are placed ſingly, one on each ſide of every ring of the abdomen; through theſe the inſect is ſuppoſed to breathe: this ſingular circumſtance in their reſpiration forms another peculiar character of inſects.

THE LIMBS, or the organs uſed by the inſect for moving it's body, and for defending itſelf, are the tail, the ſting, the feet, the wings, the halteres or poiſers.

THE TAIL terminates the abdomen, and is conſtructed in a wonderful manner for anſwering the purpoſes for which it is formed, namely, to direct the motion of the inſect, to ſerve as an inſtrument of defence, or for depoſiting the eggs; the figure and ſize thereof varying in each genus and it's families. In ſome it is ſimple, *ſimplex,* and yet capable of being extended or drawn back at pleaſure. In others, *elongata,* elongated. Setaceous, ſhaped like a briſtle; *triſeta,* with three appendages like briſtles; in ſome it is forked, *furcata*; and in others it is furniſhed with a pair of forceps, *forcipata*; in the blatta and others it is *folioſa,* or like a leaf. In the ſcorpion and panorpa it is *telifera,* furniſhed with a ſting. Further particulars may be obtained from the Philoſophia Entomologica of Fabricius.

ACULEUS, or ſting, an inſtrument with which inſects wound and inſtil a poiſon; the ſting generally proceeds from the under part of the laſt ring of the belly: in ſome it is ſharp and pointed, in others formed like a ſaw. It is uſed by many inſects both as an offenſive and defenſive weapon; by others it is only uſed to pierce the ſubſtances where they mean to depoſit their eggs.

PEDES, THE FEET. Theſe are admirably adapted for their intended ſervice, to give the moſt convenient and proper motion, and from the variety in their conſtruction, their various articulations, &c. furniſh the microſcopic obſerver with a great many curious and intereſting objects: the moſt general number is ſix; ſome have eight, as the ſpider; the crab has ten; the oniſcus fourteen; the julus has from ſeventy to one hundred and twenty on each ſide. The legs of thoſe inſects that have not more than ten, are affixed to the trunk; while thoſe that exceed that number have part fixed to the trunk, the reſt to the abdomen.

The legs of inſects are generally divided into four parts. The firſt, which is uſually the largeſt, is called the *femur*; the ſecond, or *tibia*, is joined to the former, and is commonly of the ſame ſize throughout, and longer than the femur; this is followed by the third part, which is diſtinguiſhed by the name of *tarſus*, or foot; it is compoſed of ſeveral joints, the one articulated to the other, the number of the rings varying in different inſects: the tarſus is terminated by the *unguis*, or claw.

The writers on natural hiſtory, in order to render their deſcriptions clear and accurate, have given ſeveral names to the legs of inſects, from the nature of the motions produced by them.

Thus *curſorii*, from that of running; theſe are the moſt numerous.

The *ſaltatorii*, thoſe that are uſed for leaping.

The *natatorii,* thoſe that ſerve as oars for ſwimming. The thighs of the *ſaltatorii* are remarkably large, by which means they have conſiderably more ſtrength and power for leaping. The feet of the *natatorii* are flat, and edged with hairs; thus have a proper ſurface to ſtrike againſt the water, as in the dytiſcus, notonecta, &c.

Such feet as have no claws are termed MUTICI. The chelæ, or claws, are an enlargement of the extremity of the fore feet, each of which is furniſhed with two leſſer claws, which act like a thumb and finger, as in the crab.

The under part of the feet, in ſome inſects, is covered with a kind of bruſh or ſponge, by which they are enabled to walk with eaſe on the moſt poliſhed ſubſtances, and in ſituations from which it would ſeem that they muſt neceſſarily fall.

> "They tread the ceiling, an inverted floor,
> And from it's precipice depend ſecure."

Many inſects can only move the thigh in a vertical direction; while others can move it in various directions. The progreſſive motion of inſects, and the various methods employed to effect it, will be found a very curious and important ſubject, and well worthy the attention of the natural hiſtorian. The mechanic will not find it loſt labour if he beſtows ſome time on the ſame ſubject. Very little has been done on this head, and that principally by Mr. de Reaumur, in his excellent Memoires; and by M. Weiſs, in a memoir publiſhed in the Journal de Phyſique for 1771. The reader may alſo conſult Borelli de Motu Animalium.

Motion is one of the principal phænomena of nature, and as it were the ſoul of our ſyſtem; and is as admirable in the ſmalleſt animal as in the univerſe at large. It may not be amiſs juſt to notice here, that there are ſome inſects of the beetle kind, which contradict an aſſertion of Borelli's, that an animal puts in action each foot on one ſide before it moves thoſe on the oppoſite ſide; whereas theſe employ in walking the two moſt diſtant feet on the ſame ſide, and the middle foot on the oppoſite; a method which is firm and natural.

THE WINGS, thoſe organs by which the inſect is enabled to fly; ſome have only two, others are furniſhed with four, two on each ſide; theſe are in ſome of the ſame ſize, in others the superior ones are much larger than the inferior. The variety in the form and ſtructure of the wings is almoſt infinite; the beauty of their colouring, the art with which they are connected to the body, the curious manner in which ſome are folded up, the fine articulations provided for this purpoſe, by which they are laid up in their caſes when out of uſe, and yet ready to be extended in a moment for flight; together with the various ramifications, by which the nouriſhing juices are circulated, and the wing ſtrengthened, afford a fund of rational inveſtigation highly entertaining, exhibiting, particularly when examined by the microſcope, a moſt wonderful diſplay of divine wiſdom and power. The more delicate and tranſparent wings are covered and protected by ELYTRA, or caſes, which are generally hard and opake, often highly poliſhed, adorned with ornamental flutings, and ſtudded with brilliants. The wings of moths and butterflies are moſtly farinaceous, covered with a fine duſt, that occaſions thoſe beautiful colours with which they are ſo elegantly painted; for ſtripped of theſe, the wing is tranſparent and colourleſs. By the aſſiſtance of the microſcope, we diſcover that this duſt is a regular aſſemblage of organized ſcales, which will be more particularly deſcribed hereafter. A few of theſe, as ſeen in the microſcope, are exhibited in Plate 16, Fig. F E H I.

The following names are made uſe of to deſcribe the different kinds of wings. They are firſt diſtinguiſhed, with reſpect to their ſurfaces, into SUPERIOR and INFERIOR. The part next the head is called the ANTERIOR part, that neareſt the tail the POSTERIOR part. THE INTERIOR part is that next the abdomen; THE EXTERIOR part is the outermoſt edge.

Thoſe wings are termed PLICATILES, which are folded when the inſect is at reſt, as in the waſp.

PLANÆ, thoſe which are incapable of being folded.

ERECTÆ, whoſe ſuperior ſurfaces are brought in contact when the inſect is at reſt, as in the ephemera, papiliones, &c.

PATENTES, if they are extended horizontally when the inſect is at reſt, as in the phalænæ geometræ.

INCUMBENTES, thoſe inſects which, when they are not in motion, cover horizontally with their wings the ſuperior part of the abdomen.

DEFLEXÆ; theſe are alſo incumbentes, but not horizontally, the outer edges declining towards the ſides.

REVERSÆ are alſo deflexæ, with this addition, that the edges of the inferior wing project from under the anterior part of the ſuperior one.

DENTATÆ, with ſcolloped edges.

CAUDATÆ; in theſe ſome of the fibres of the wing are extended beyond the margin into a kind of tail.

RETICULATÆ, when the veins or membranes of the wings put on the appearance of net-work.

The wings are further diſtinguiſhed by their ornaments being painted with ſpots (*maculæ*), bands (*faſciæ)*, ſtreaks (*ſtrigæ*): when theſe are extended lengthways, they are called lines (*linæ*); and if with dots, *punctæ*; one or more rings are termed eyes, *ocellus;* if the ſpots are ſhaped like a kidney, they are termed *ſtigmata.*

The elytra, or cruſtaceous caſes of the wings, are extended when the inſect flies, and ſhut when it reſts, forming a longitudinal ſuture down the middle of the back; they are of various ſhapes, and are diſtinguiſhed by the following names:

ABREVIATA, when they are ſhorter than the abdomen.

TRUNCATA, when the extremity terminates in a tranſverſe direct line.

SERRATA, having the external margin edged with teeth or notches.

SPINOSA, when the exterior ſurface is covered with ſmall ſharp points.

SCABRA, when it is very rough.

STRIATA, marked with ſlender longitudinal furrows.

PORCATI, having ſharp longitudinal ridges.

SULCATI, with deep furrows.

HEMELYTRA, when the caſes are neither ſo hard as the elytra, nor ſo delicate as the tranſparent wing.

Under the wings of moſt inſects, which have only two, there is a ſmall head placed on a ſtalk, frequently under a little arched ſcale; theſe are called HALTERES, poiſers; they appear to be rudiments of the hinder wings: it has been ſuppoſed that they ſerve to keep the body in equilibrio when the inſect is flying.

The bodies of inſects are covered with a hard ſkin, which anſwers the purpoſe of an internal ſkeleton, and is one of the diſtinguiſhing characters of an inſect. All quadrupedes, birds, and fiſhes, have an internal ſkeleton of bones to which the muſcles are fixed; but the whole interior body of an inſect is compoſed of ſoft fleſh, and the muſcles are affixed to the exterior ſkeleton or ſkin, which in theſe anſwer the purpoſe of bones. The ſkin ſerves as a continent to the whole inſect, covering the body, connecting the parts, and maintaining them in their proper places. This external covering is very ſtrong in thoſe inſects, which, by the nature of their life, are expoſed to ſtrong friction, or violent compreſſion; but is more tender and delicate in thoſe which are not ſo expoſed. The ſkin of inſects, like that of larger animals, is porous; the pores in ſome ſpecies are very large. Many inſects often change or caſt off their ſkin; this exuvia forms an excellent object for the microſcope.

Another diſtinguiſhing criterion of inſects is the colour of their blood, which is never red; this, at firſt ſight, ſeems liable to ſome objections, on account of the drop of red liquor which is often procured from ſmall inſects when ſqueezed or preſſed to pieces. It does not appear, however, that this is the blood of the little animal; when it exiſted as a worm there was no ſuch appearance, and when they exiſt as a fly it is only found in the eye, and not in the body, which would be the caſe if it circulated in the veins of the inſects. It is probable there is a circulation of ſome fluid analagous to the blood in moſt inſects: with the aſſiſtance of the microſcope this circulation may be perceived in many; but the circulating liquor is not red.

To theſe diſcriminating characteriſtics we may alſo add the following particulars: 1. That the body of inſects is divided by inciſuræ, or tranſverſal diviſions, from whence they take their name.

2. That they are furniſhed with antennæ, which are placed upon the fore part of the head; theſe are jointed, and moveable in various directions.

3. That no inſect in it's perfect ſtate, or after it has gone through all it's transformation, has leſs than ſix legs, though many have more. There are ſome moths, whoſe two fore feet are ſo ſmall as ſcarcely to deſerve that name. A proper attention to the nature and number of the feet of inſects would tend to fix their real rank in that ſcale of animated nature, which is handed down to us in the ſacred ſcriptures; a ſcale which, from the lively repreſentations it holds forth, as well as their moral applications to the purpoſes of life, and the ſource from whence it is derived, ſhews that it is replete with the moſt important information.

4. That inſects have neither the organs of ſmell nor hearing; at leaſt they have not as yet been diſcovered, though it is reported that Fabricius has lately ſound and deſcribed the organs of hearing in the lobſter.

5. That they do not reſpire air by the mouth, but that they inſpire and exhale it, by means of organs which are placed on the body.

6. That they move the jaws from right to left, not up and down.

7. That they have neither eye-lid nor pupil.

To theſe we may alſo add, that the mechaniſm reſulting from the LIFE of inſects is not of ſo compound a nature as in animals of a larger ſize. They have leſs variety of organs, though ſome of the organs are more multiplied; and it is by the number and ſituation of theſe that their rank in the great ſcale of beings is to be determined.

Theſe characters are often united in the ſame inſect; there are, however, ſome ſpecies in which one or two of them are wanting.

Every microſcopic obſerver, who wiſhes to avail himſelf of the diſcoveries of other writers, or to communicate intelligibly his own, will find it neceſſary to make himſelf maſter of the various claſſes, genera, &c. into which inſects have been divided by LINNÆUS. All ſyſtems have their defects, and it is highly probable that this may be the caſe with that of the celebrated Linnæus: but the purpoſe of ſcience is anſwered by uſing thoſe diſcriminations which are generally adopted.

The following general idea of the Linnæan claſſes may ſerve as a foundation for this knowledge: a fuller account may be obtained by conſulting the under-mentioned works.

Inſtitutions of Entomology, a tranſlation of Linnæus's Ordines et Genera Inſectorum, or Syſtematic Arrangement of Inſects, &c. by Thomas Pattiſon Yeats.

Fundamenta Entomologica, or an Introduction to the Knowledge of Inſects, tranſlated from Linnæus by W. Curtis, author of the Flora Londinenſis, Botanical Magazine, &c.

The

The Genera Inſectorum of Linnæus, exemplified by various Specimens of Engliſh Inſects, drawn ſrom Nature, by James Barbut.

Claſs the firſt. COLEOPTRA. The inſects of this claſs have four wings; the upper ones, called the elytra, are cruſtaceous, formed of a hard bony ſubſtance, which, when ſhut, form a longitudinal ſuture down the back, as in the ſcarabæus, melolontha, or cockchaffer, &c. &c.

2. HEMIPTERA. Theſe have alſo four wings; but the elytra are different, being half cruſtaceous, half membranaceous: the wings do not form a longitudinal ſuture, but extend the one over the other, as in the gryllus, graſshopper, &c.

3. LEPIDOPTERA. Thoſe which have four membranaceous wings covered with fine ſcales, as the butterflies and moths.

4. NEUROPTERA. Theſe have four membranaceous tranſparent wings, which are generally reticulated, as in the libellula, or dragon flies.

5. HYMENOPTERA. Theſe, like the preceding claſs, have four membranaceous wings; but the abdomen is furniſhed with a ſting, as in the bees, waſps, &c.

6. DIPTERA. Theſe have only two wings, as common houſe flies, gnats, &c.

7. APTERA. Theſe have no wings, as ſpiders, lice, acari, &c.

## OF THE TRANSFORMATION OF INSECTS.

Inſects are further diſtinguiſhed from other animals by the wonderful changes that all, except thoſe of the aptera claſs, paſs through. Moſt animals retain, during their whole life, the ſame form which they receive at their birth; but inſects go through wonderful exterior and interior changes, inſomuch that the ſame individual, at it's birth and middle ſtate, differs eſſentially from that under which it appears when arrived at a ſtate of maturity; and this difference is not confined to marks, colour, or texture, but is extended to their form, proportion, motion, organs, and habits of life.

The ancient writers on natural hiſtory were not unacquainted with theſe transformations, but the ideas they entertained of them were very imperfect, and often erroneous. It was not till towards the latter end of the laſt century that any juſt conception of this ſubject was formed, and the myſtery was then unveiled by thoſe two great anatomiſts Malphigi and Swammerdam, who obſerved theſe inſects under every appearance, and by diſſecting them at the time juſt preceding their changes, were enabled to prove that the moth and butterfly grow and ſtrengthen themſelves, and that their members are formed and unfolded, under the figure of the inſect we call a caterpillar; and they alſo ſhewed, that it is not difficult to exhibit in theſe all the parts of the future moth, as it's wings, legs, antennæ, &c. and conſequently that the changes which are apparently ſudden to our eyes, are gradually formed under the ſkin of the animal, and only appear ſudden to us, becauſe the inſect then gets rid of a caſe which had before concealed his real members. Theſe transformations clearly prove, that without repeated experience every thing in nature would appear a myſtery: for who, on conſidering by the mere light of nature or reaſon a gnat or butterfly in their fly or perfect ſtate, could have diſcovered the relation which in this ſtate and form it bears to the ſeveral changes of ſtate, and their correſponding forms, through which it has paſſed,* and which are to appearance as diſtinct as difference can make them.

The life of thoſe inſects which paſs through theſe various changes, may be divided into four principal parts, each of which will be found truly worthy of all the attention of the microſcopic obſerver.

The firſt change is from the EGG into the LARVA; or, as it is more generally called, into the worm or caterpillar.

From the LARVA it paſſes into the PUPA, or chryſalis ſtate.

From the PUPA into the imago or fly ſtate.

Few ſubjects can be found that are more expreſſive of the extenſive goodneſs of Divine Providence, than theſe transformations, in which we find the occaſional and temporary parts and organs of theſe little animals ſuited and adapted with the moſt minute exactneſs to the immediate manner and convenience of their exiſtence; which again are ſhifted and changed, upon the inſects commencing a new ſcene and ſtate of action.

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* All is phænomenon, and type on earth,
Replete with ſacred and myſterious birth.

Brooke's Univerſal Beauty, b. v.

In it's larva ſtate the inſect appears groveling, heavy, and voracious, in the form of a worm, with a long body, compoſed of ſucceſſive rings; crawling along by the aſſiſtance of theſe, or ſmall little hooks, which are placed on the ſide of the body. It's head is armed with ſtrong jaws, it's eyes ſmooth, entirely deprived of ſex, the blood circulating from the hind part towards the head. It breathes through ſmall apertures, which are ſituated on each ſide of the body, or through one or more tubes placed in the hinder part thereof. While it is in the larva ſtate, the inſect is as it were maſked, and it's true appearance concealed; for under this maſk the more perfect form is hidden from the human eye.

In the pupa ſtate the inſect may be compared to a child in ſwaddling clothes; it's members are all folded together under the breaſt, and incloſed within one or more coverings, remaining there without motion. While in this ſtate, no inſect but thoſe of the hemiptera claſs take any nouriſhment. This change is effected various ways; in ſome inſects the ſkin of the larva opens, and leaves a paſſage, with all it's integuments; in others, the ſkin hardens and becomes a ſpecies of cone, which entirely conceals the inſects; others form or ſpin cones for themſelves, and in this ſtate they remain till the parts have acquired ſufficient firmneſs, and are ready to perform their ſeveral offices.

The inſect then caſts off the ſpoils of it's former ſtate, and appears in it's imago or perfect form; for it has now attained the ſtate of organical perfection, which anſwers to the rank it is to hold in the corporeal world. They are now furniſhed with wings, magnificently adorned; ſoar above and deſpiſe their former purſuits, wing the ſoft air, chuſe their mates, and tranſmit their nature to a ſucceeding race. Their members, which in the preceding ſtate were wrapped up, ſoft, and motionleſs, now diſplay themſelves, grow ſtrong, and are put in exerciſe. The interior changes are as conſiderable as thoſe of the exterior form, and that in proportion as the firſt ſtate differs from the laſt; ſome organs acquire greater ſtrength and firmneſs, others are rendered more delicate, ſome are ſuppreſſed, and ſome unfolded, which did not ſeem to exiſt in the former ſtages of it's life.

" Who that beholds the ſummer's gliſt'ning ſwarms,
Ten thouſand thouſand gaily gilded forms,
In volant dance of mix'd rotation play,
Baſk in the beam, and beautify the day;
Who'd think theſe airy wantons ſo adorn,
Were late his vile antipathy and ſcorn;
Prone to the duſt, or reptile thro' the mire,
And ever thence unlikely to aſpire?
Or who, with tranſient view beholding, loaths
Thoſe crawling ſects, whom vileſt ſemblance cloahs:
Who with corruption hold their kindred ſtate,
As by contempt, or negligence of fate;
Could think that ſuch, revers'd by wond'rous doom,
Sublimer pow'rs and brighter forms aſſume;

From death their future happier life derive,
And, tho' apparently entomb'd, revive;
Chang'd, thro' amazing tranſmigration, riſe,
And wing the regions of unwonted ſkies."*

## OF THE LARVA STATE.

As the larvæ (caterpillars) of the moth and butterfly † form the moſt numerous family among the tribe of inſects, and have been more particularly obſerved than any other kind, perhaps on account of the uſefulneſs of one of their number, and are therefore beſt known, we ſhall firſt deſcribe them, and their various changes from this ſtate to their laſt and perfect form, and then proceed to thoſe inſects which differ moſt from the caterpillar in one or all of their various changes.

The greater part of thoſe inſects which come forth in ſpring or ſummer periſh or diſappear at the approach of winter; there are very few, the period of whoſe life exceeds that of a year; ſome ſurvive the rigours of winter, being concealed and buried under ground; many are hid in the bark of trees, and others in the chinks of old walls; ſome, like

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* Brooke's Univerſal Beauty.

† The butterflies are diſtinguiſhed from the moth by the time of their flying abroad, and by their antennæ; the butterflies appear by day, their antennæ are generally terminated by a little knob; the moths fly moſtly in the evening, and their antennæ are either ſetaceous or pectinated.

the caterpillar of the brown-tailed moth,* which was ſo uncommonly numerous and deſtructive near London, in the year 1782, at the approach of winter not only ſecure and ſtrengthen the web in which the ſociety inhabit, and thus protect themſelves from impertinent intruders, but each individual alſo ſpins a caſe for itſelf, where it reſts in torpid ſecurity, notwithſtanding the inclemency of the ſeaſon, till the ſpring animates it afreſh, and informs them that the all-bountiful Author of nature has provided food convenient for them. Many that are hatched in the autumn retire and live under the earth during the winter months, but in the ſpring come out, feed, and proceed onward to their ſeveral changes; while no ſmall part paſs the colder months in their chryſalis, or pupa ſtate: but the greater number of the caterpillar race remain in the egg, being carefully depoſited by the parent fly in thoſe places where they will be hatched with the greateſt ſafety and ſucceſs; in this ſtate the latent principle of life is preſerved till the genial influences of the ſpring call it into action, and bring forth the young inſect to ſhare the banquet that nature has provided; then wherever we turn, or wherever we move, we find this inſect in one ſhape or another.

"When firſt breaks forth the bright enliv'ning ray;

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——— The gay, the quick'ning inſects riſe,
And gilded ſquadrons ſtrike our wond'ring eyes;
Muſic flies wanton from ten thouſand wings,
And life and joy through ev'ry region rings."—†

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* Curtis's ſhort hiſtory of the brown-tailed moth.

† Brooke's Univerſal Beauty.

All caterpillars are hatched from the egg, and when they firſt proceed from it are generally ſmall and feeble, but grow in ſtrength as they increaſe in ſize. The body of the caterpillar is divided into twelve rings; the head is connected with the firſt, and is hard and cruſtaceous. No caterpillar of the moth or butterfly has leſs than eight, or more than ſixteen feet; thoſe which have more than ſixteen are not the larva of the moth or butterfly; the ſix firſt feet are cruſtaceous, pointed, and fixed to the three firſt rings of the body; theſe feet are the covering to the ſix future feet of the moth; the other ſix feet are ſoft and flexible, or membranaceous; they vary both in figure and number, and are proper only to the larva ſtate: with reſpect to their external figure, they are either ſmooth or hairy, ſoft to the touch, or hard like ſhagreen, beautifully adorned with a great variety of the moſt lively tints; on each ſide of the body nine little oval holes are placed, which are generally conſidered as the organs of reſpiration. There are on each ſide of the head of the caterpillar five or ſix little black ſpots, which are ſuppoſed to be it's eyes. Theſe creatures vary in ſize, from half an inch long to four and five inches.

The caterpillar, whoſe life is one continued ſucceſſion of changes, often moults it's ſkin before it attains it's full growth. Theſe changes are the more ſingular, becauſe when the caterpillar moults, it is not ſimply the ſkin that is changed; for we find in the exuvia the ſkull, the jaws, and all the exterior parts, both ſcaly and membranaceous, which compoſe it's upper and under lip, it's antennæ, palpi, and even thoſe cruſtaceous pieces within the head, which ſerve as a fixed baſis to a number of muſcles; we further find in the exuvia, the ſpiracula, the claws, and ſheaths of the anterior limbs, and in general all that is viſible of the caterpillar.

The new organs were under the old ones as in a ſheath, ſo that the caterpillar effects the changes by withdrawing itſelf from the old ſkin, when it finds itſelf lodged in too narrow a compaſs. But to effect this change, to puſh off the old covering, and bring forwards the new, is a work of labour and time. Thoſe caterpillars who live in ſociety, and have a kind of neſt or habitation, retire there to change their ſkin, fixing the hooks of the feet, during the operation, firmly in the web of their neſt. Some of the ſolitary ſpecies ſpin at this time a ſlender web, to which they affix themſelves. A day or two before the critical moment approaches, the inſect ceaſes to eat, and loſes it's uſual activity; in proportion as the time of change approaches, the colour of the caterpillar becomes more feeble, the ſkin hardens and withers, and is ſoon incapable of receiving thoſe juices by which it was heretofore nouriſhed and ſupported. The inſect may now be ſeen, at diſtant intervals, to elevate it's back, and ſtretch itſelf to it's utmoſt extent; ſometimes to lift up the head, move it a little from ſide to ſide, and then let it fall again; near the change, the ſecond and third rings are ſeen to ſwell conſiderably; by theſe internal efforts the old parts are ſtretched and diſtended as much as poſſible, an operation which is attended with much difficulty, as the new parts are all weak and tender. However, by repeated exertions, all the veſſels which conveyed the nouriſhment to the exterior ſkin are diſengaged, and ceaſe to act, and a ſlit is made on the back, generally beginning at the ſecond or third ring; the new ſkin may now be juſt perceived, being diſtinguiſhed by the freſhneſs and brightneſs of it's colour; the caterpillar then preſſes the body like a wedge into this ſlit, by which means it is ſoon opened from the firſt down to the fourth ring; this renders it large enough for the inſect to paſs through, which it ſoon effects in a very curious manner. The caterpillar generally faſts a whole day after each moulting, for it is neceſſary that the parts ſhould acquire a certain degree of conſiſtency, before it can live and act in it's uſual manner; many alſo periſh under the operation.

The inſect always appears much larger after it has quitted the exuvia; the body had grown under the old ſkin, till it was become too large for it: now as the growth was gradual, and the parts ſoft, the ſkin preſſed them together, ſo that they lay in a ſmall ſpace; but as ſoon as the ſkin is caſt off, they are as it were liberated from their bonds, and diſtend themſelves conſiderably. Some caterpillars, in changing their ſkin, from ſmooth become covered with fine hair; while others, that were covered with this fine hair, have the laſt ſkin ſmooth.*

## OF THE PUPA.

Before we deſcribe the change of the larva into the pupa ſtate, it will be neceſſary to give the reader an account of thoſe names by which naturaliſts diſtinguiſh the different appearances of inſects in the pupa ſtate.

It is called COARCTATA, when it is ſtraitened or confined to a caſe of a globular form, which has no reſemblance to the inſect it contains.

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* Valmont de Bomare Dictionnaire Univerſel d'Hiſtoire Naturelle, vol. ii. 2d edit. 12mo. p. 394.

It is called OBTECTA, diſguiſed or ſhrowded, when the inſect is enveloped in a cruſtaceous covering, conſiſting of two parts, one of which ſurrounds the head and thorax, the other the abdomen.

It is termed INCOMPLETA, when the pupa has perceptible wings and feet, but cannot move them.

SEMICOMPLETA; theſe can walk or run, but have only the rudiments of wings. The difference between the pupa and the larva of this claſs is very inconſiderable, as they eat, walk, and act, juſt as they did in their primitive ſtate; the only remarkable difference is a kind of caſe, which contains the wings that are to be developed in their fly ſtate.

COMPLETA; thoſe deſigned by this name take their perfect form at their birth, and do not paſs, like other inſects, through a variety of ſtates, though they often change their ſkin.

It is a general rule, that all winged inſects paſs through the larva and pupa ſtate before they aſſume their perfect form: there are alſo inſects which have no wings, and yet undergo ſimilar transformation, as the bed bug, the flea, &c. Other inſects, which have no wings, and which always remain without them, never paſs through the pupa ſtate, but are ſubject to conſiderable changes, as well with reſpect to the number as the figure of their parts; thus mites have four pair of feet, and two ſmaller ones at the fore part of the body, near the head; yet ſome of theſe are born with only three pair of feet, the fourth is not perceived till ſome time after their birth.* The figure of the monoculus quadricornis of Linnæus (Fauna Suecica, edit. Stockholm, 1761, No. 2049) changes conſiderably after it's birth.* The julus is an inſect with a great number of feet, ſome ſpecies having an hundred pair and upwards. M. De Geer has given a deſcription of one with more than two hundred pair,† and yet theſe at their birth have only three pair, the reſt are not perceived till ſome time after.

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* De Geer Memoires pour ſervir à l'Hiſtoire des Inſectes, tom. 1. p. 154.

We ſhall now return to the caterpillar, and take notice of the care and proviſion it makes to paſs from the larva ſtate into that of the pupa, or chryſalis; which is, in general, a ſtate of imperfection, inactivity, and weakneſs, through which the inſect, when it has obtained a proper ſize, muſt paſs; and in which it remains often for months, ſometimes for a whole year, expoſed, without any means of eſcaping, to every event; and in which it receives the neceſſary preparations for it's perfect ſtate, and is enabled once more to appear upon the tranſitory ſcene of time. During it's paſſage from one ſtate to the other, as well as when it is in the pupa form, the microſcopical obſerver will find many opportunities of exerciſing his inſtrument.

The tranſitions of the caterpillar from one ſtate to another, are to it a ſubject of the moſt intereſting nature; for in paſſing through them, it often runs the riſk of loſing it's life, and life is the greateſt boon the Creator can beſtow; it is ever accompanied with a degree of delight proportioned to the ſtate in which the creature exiſts, and the uſe it makes of the gift it has received. If the caterpillar could therefore foreſee the efforts and exertions it muſt make to put off it's preſent form, and the ſtate of weakneſs and impotence under which it muſt exiſt while in the pupa ſtate, it would undoubtedly chuſe the moſt convenient place, the moſt advantageous ſituation, for the performance of this arduous operation; one where it would be the leaſt expoſed to danger, when it had neither ſtrength to reſiſt, nor ſwiftneſs to avoid the attack of an enemy.

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* De Geer Memoires pour ſervir à l'Hiſtoire des Inſectes, tom. 1, p. 155.

† Memoires des Sçavans etrangers, tom. 3, p. 61.

All theſe neceſſary inſtructions the caterpillar receives from the influence of an all-regulating Providence, which conveys the proper information to it by it's own ſenſations: hence, when the critical period approaches, it proceeds as if it knew what would be the reſult of it's operations. Different ſpecies prepare themſelves for this ſtate in different ways, ſuited to their nature and the length of time they are to remain in this ſtate.

When the caterpillar has attained to it's full growth, and the parts of the future butterfly are ſufficiently formed beneath it's ſkin, it prepares for it's change into the pupa ſtate; it ſeeks for a proper place in which to perform the important buſineſs: the different methods employed by theſe little animals to ſecure this ſtate of reſt, may be reduced to four: 1. Some ſpin webs, or cones, in which they incloſe themſelves; 2. Others conceal themſelves in little cells, which they form under ground; 3. Some ſuſpend themſelves by their poſterior extremity; 4. While others are ſuſpended by a girdle that goes round their body. We ſhall deſcribe the variety in theſe, as well as the induſtry uſed in conſtructing them, after we have gone through the manner in which the caterpillar prepares itſelf for and paſſes through the pupa ſtate.

Preparatory to the change, it ceaſes to take any food, empties itſelf of all the excrementitious matter that is contained in the inteſtines, voiding at the ſame time the membrane which ſerved as a lining to theſe and the ſtomach. It generally perſeveres in a ſtate of reſt and inactivity for ſeveral days, which affords the external and internal organs that are under the ſkin an opportunity of gradually unfolding themſelves. In proportion as the change into the pupa form approaches, the body is obſerved often to extend and contract itſelf; the hinder part is that which is firſt diſengaged from the caterpillar ſkin; when this part of the body is free, the animal contracts and draws it up towards the head; it then liberates itſelf in the ſame manner from the two ſucceeding rings, conſequently the inſect is now lodged in the fore part of it's caterpillar covering; the half which is abandoned remains flaccid and empty, while the fore part is ſwoln and diſtended. The animal, by ſtrong efforts, ſtill forcing itſelf againſt the fore part of the ſkin, burſts the ſkull into three pieces, and forms a longitudinal opening in the three firſt rings of the body; through this it proceeds, drawing one part after the other, by alternately lengthening and ſhortening, ſwelling and contracting the body and different rings; or elſe, by puſhing back the exuvia, gets rid of it's odious reptile form.

The caterpillar, thus ſtripped from it's ſkin, is what we call the pupa, chryſalis, and aurelia, in which the parts of the future moth are incloſed in a cruſtaceous covering, but are ſo ſoft, that the ſlighteſt touch will diſcompoſe them. The exterior part of the chryſalis is at firſt exceedingly tender, ſoft, and partly tranſparent, being covered with a viſcous fluid; this ſoon dries up, thickens, and forms a new covering for the animal, capable of reſiſting external injuries; a caſe, which is at the ſame time the ſepulchre of the caterpillar, and the cradle of the moth; where, as under a veil, this wonderful transformation is carried on.

The pupa has been called a chryſalis, or creature made of gold, from the reſplendent yellow colour with which ſome kinds are adorned. M. de Reaumur has ſhewn us whence they derive this rich colour; that it proceeds from two ſkins, the upper one a beautiful brown, which lays upon or covers a highly-poliſhed and ſmooth white ſkin: the light reflected from the laſt, in paſſing through, gives it the golden yellow, in the ſame manner as this colour is often given to leather; ſo that the whole appears gilded, although no gold enters into the tincture. The chryſalis of the common white butterfly furniſhes a moſt beautiful object for the lucernal opake microſcope.

Thoſe who are deſirous to diſcover diſtinctly the various members of the moth in the pupa, ſhould examine it before the forementioned fluid is dried up, when it will be found to be only the moth, with the members glued together; theſe, by degrees, acquire ſufficient force to break their covering, and diſengage themſelves from the bands which confine them.

To examine the moth concealed under the ſkin of a caterpillar, one of them ſhould be taken at the laſt change; when the ſkin begins to open, it ſhould be drowned in ſpirits of wine, or ſome ſtrong liquor, and be left therein for ſome days, that it may take more conſiſtency and harden itſelf; the ſkin of the caterpillar may then be eaſily removed: the chryſalis, or feeble moth, will be firſt diſcovered, after which the tender moth may be traced out, and it's wings, legs, antennæ, &c. may be opened and diſplayed by an accurate obſerver.

The parts of the moth, or butterfly, are not diſpoſed exactly in the ſame manner in the body of the caterpillar, as when left naked in the chryſalis. The wings are longer and narrower, being wound up into the form of a cord, and the antennæ are rolled up on the head; the tongue is alſo twiſted up and laid upon the head, but in a very different manner from what it is in the perfect animal; and different from that which it lies in within the chryſalis; ſo that it is by a progreſſive and gradual change, that the interior parts are prepared for the moth and pupa ſtate. The eggs, hereafter to be depoſited by the moth, are alſo to be found not only in the chryſalis, but in the caterpillar itſelf, arranged in their natural and regular order.

The time which the moth, or butterfly, remains in the pupa ſtate is not always the ſame, varying in different ſpecies, and depending alſo upon the warmth of the weather, and other adventitious circumſtances; ſome remain in that ſituation for a few weeks; others do not attain their perfect form for eight, nine, or eleven months: this often depends on the ſeaſon in which they aſſume the pupa form, or rather on the time of their birth. Some irregularities are alſo occaſioned by the different temperature of the air, by which they are retarded or accelerated, ſo as to be brought forward in the ſeaſon beſt ſuited to their nature and the ends of their exiſtence. I have heard of an inſtance, where the pupa produced from caterpillars of the ſame eggs, nouriſhed in the ſame manner, and which all ſpun up within a few days of each other in the autumn, came into the fly ſtate at three different and diſtant periods, viz. one-third of them the ſpring following their change, one-third more the ſucceeding ſpring, and the remainder the ſpring after; making three years from their firſt hatching; a further and manifeſt proof of the beauty and wiſdom of the laws of Divine order, which are continually operating for the beſt intereſts of all created beings. As the transformation of inſects is retarded by cold, and accelerated by heat, the ordinary period of theſe changes may ſometimes be altered, by placing them in different degrees of heat or cold; by theſe they may be awakened ſooner to a new ſtate of exiſtence, or kept in one of profound ſleep.*

There are ſome caterpillars who remain in their cone eight or nine months, before they become complete chryſaliſes; ſo that their duration in the pupa ſtate is much ſhorter than it naturally appears to be.

As ſoon as the moth acquires ſufficient ſtrength to break the bonds which ſurround it, and of which it is informed by it's internal ſenſations, it makes a powerful effort to eſcape from it's priſon, and view the world with new-formed eyes. The moth frees itſelf from the pupa with much greater eaſe than the pupa from the caterpillar; for the caſe of the pupa becomes ſo dry, when the moth is near the time of throwing off it's covering, that it will break to pieces if it be only gently preſſed between the fingers; and very few of the parts will be found, on examination, to adhere to the body. Hence when the inſect has acquired a proper degree of ſolidity, it does not require any great exertion to ſplit the membrane which covers it. A ſmall degree of motion, or a little inflation of the body, is ſufficient for this purpoſe; theſe motions reiterated a few times, enlarge the hole, and afford the moth room to eſcape from it's confinement. The opening through which they paſs is always at the ſame part of the ſkin, a little above the trunk, between the wings and a ſmall piece which covers the head; the different fiſſures are generally made in the ſame direction. If the outer caſe is opened, it is eaſy to diſcover the efforts the inſect makes to emancipate itſelf from it's ſhell; when the operation begins, there ſeems to be a violent agitation in the humours contained in the little animal; the fluids ſeem to be driven with rapidity through all the veſſels, and it is ſeen to agitate it's legs, &c. as it were ſtruggling to get free; theſe efforts, as we have already ſaid, ſoon break it's brittle ſkin.

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* Reaumur Memoires ſur les Inſectes, tom. 2, mem. 1.

The looſening the exterior bands of the pupa is not the only difficulty many moths have to encounter with; it has often alſo to pierce the cone, or caſe, in which it has been incloſed, and that at a time when it's members are very feeble, when it is no longer furniſhed with ſtrong jaws to pierce and cut it's way through; but, by the regular laws of Divine order, means are furniſhed to every creature of attaining the end for which it was produced: thus, in the preſent caſe, ſome of theſe inſects are provided with a liquor with which they ſoften and weaken the end of the cone; ſome leave one end feeble, and cloſe it only with a few threads, ſo that a ſlight effort of the head enables the moth to burſt the priſon doors, and immerge into day.

When the moth firſt ſees the day, it is humid and moiſt; but this humidity ſoon evaporates, the interior parts dry and harden as well as the exterior; the wings, which are crumpled, or thick and ſmall, extend themſelves, are ſtrengthened and hardened inſenſibly, and the fibres which were at firſt flexible become hard and ſtiff; even ſo ſtiff, that Malphigi conſidered them as bones: in proportion as theſe fibres harden, the fluid which circulates within them, and extends the wings, loſes it's force; ſo that if any extraneous circumſtance prevents the motion of this fluid, at the firſt inſtant of the moth's eſcape from it's former ſtate, the wing will then become ill-ſhaped; often expanding with ſuch rapidity, that the naked eye cannot trace it's unfolding. The wing, which was ſcarce half the length of the body, acquires in a few minutes it's full ſize, ſo as to be nearly five times as large as they were before: nor is it the wings only which are thus increaſed; all their ſpots and colours, heretofore ſo minute as to be ſcarce diſcernible, are proportionally extended, ſo that what before appeared as only ſo many unmeaning and confuſed points, become diſtinct and beautiful ornaments; and thoſe that are furniſhed with a tongue, or trunk, curl and coil it up.

When the wings are unfolded, the tongue rolled up, the moth ſufficiently dried, and the different members ſtrengthened, it takes it's flight. Moſt of them, ſoon after they have attained their perfect ſtate, void an excrementitious ſubſtance, which M. de Reaumur thinks is the laſt time of their doing it; that they reject very little, if any, during the reſt of their lives.

If the moth is opened down the belly, and the fatty parts which fill it are removed, the groſs artery, which has been called the heart, will be viſible, and the contractions and dilations, by which it puſhes forwards the liquor it contains, may be eaſily obſerved. One of the moſt remarkable circumſtances is, that the circulation of this fluid in the moth is directly contrary to that which took place in the caterpillar; in this the liquor moved from the tail to the head, whereas in the moth it moves from the head to the tail; ſo that the fluid which anſwers the purpoſes of the blood in the moth, goes from the ſuperior towards the inferior parts; but in the voracious ſenſual caterpillar the order is inverted, it proceeds from the inferior towards the ſuperior parts.

The food of the caterpillar is groſs and ſolid, and even this it is obliged to earn with much labour and danger; but when freed as it were from the jaws of death, and arrived at it's perfect form, the pureſt nectar is it's portion, and the air it's element. It was ſupplied with coarſe food, in the firſt ſtate, by the painful operation of it's teeth, which was afterwards digeſted by a violent trituration of the ſtomach. The inteſtines are now formed in a more delicate manner, and ſuited to a more pure and elegant aliment, which nature has prepared for it's uſe, from the moſt fragrant and beautiful flowers. Many internal parts of the caterpillar diſappear in the chryſalis, and many that could not be perceived before are now rendered viſible: the interior changes are not leſs ſurprizing than thoſe of the exterior form, and are, properly ſpeaking, creative of them; for it is from theſe the exterior form originates, and to theſe it always correſponds. In a word, the creature that heretofore crept upon the earth, now flies freely through the air; and far from creating our averſion by it's frightful prickles and foul appearance, it attracts our notice by the moſt elegant ſhape and cloathing.*

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* Swammerdam's Book of Nature, p. 10.

Yon maggot, vileſt offspring of the earth,
Anſwers the genial baſeneſs of his birth:
Lo! where he rolls and battens with delight
In filth, to ſmell offenſive, foul to ſight!
Well pleas'd he drinks the ſtench, the dirt devours,
And prides him in the puddle of his pow'rs;
Careleſs, unconſcious of the beauteous gueſt,
Th' internal ſpeck committed to his breaſt;
Yet in his breaſt th' internal ſpeck grows warm,
And quickens into motion, life, and form:
Far other form than that it's foſterer bore,
High o'er it's parent worm ordain'd to ſoar.
The ſon ſtill growing as the ſire decays,
In radiant plume his infant form arrays;
Matures as in a ſoft and ſilent womb,
Then op'ning, peeps from his paternal tomb;
Now ſtruggling, breaks at once into the day,
Tries his young limbs, and bids his wings diſplay;
Expands his lineaments, erects his face,
Riſes ſublime o'er all the reptile race;
From dew-dropt bloſſoms ſips the nectar'd ſtream,
And baſks within the glory of the beam. *

The induſtry of the caterpillar, in ſecuring itſelf for it's change into the chryſalis, muſt not be paſſed by; not only becauſe they naturally lead the reader to conſider and admire that Divine agency by which they are informed, but becauſe the different modes they make uſe of cannot be properly inveſtigated, without the

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* Brooke's Redemption.

the aſſiſtance of glaſſes, and are conſequently a proper ſubject for the microſcope; we ſhall ſelect from a great variety, a few inſtances, to animate the reader in theſe reſearches.

Some caterpillars, towards the time of their change, ſuſpend themſelves from the branch of a tree, with the head downwards; in this poſition they aſſume the pupa form, and from thence immerge a butterfly or moth. In order to ſuſpend itſelf in this poſition, the inſect covers with threads that part of the branch from which it means to ſuſpend itſelf; it places theſe in different directions, and then covers them with other threads, laying on ſeveral ſucceſſive thickneſſes, each new layer being ſmaller in ſize than that which preceded it; forming, when finiſhed, a little cone or hillock of ſilk, as will be found when examined by the microſcope. The caterpillar hooks itſelf by the hinder feet to this hillock; and when it has found, by ſeveral trials, that it is ſtrongly fixed thereto, throws itſelf forward, letting the body fall with the head downwards. Soon after it is thus ſuſpended, it bends the fore part of the body, keeping this bent poſture for ſome time; then ſtraitening the body, again in a little time bending it, and ſo on, repeating this operation till it has formed a ſlit in the ſkin upon the back; part of the pupa ſoon forces itſelf through this, and extends the ſlit as far as the laſt cruſtaceous feet; the pupa then forces upwards the ſkin, as we would puſh down a ſtocking, by means of it's little hooks and the motion of the body, till it has ſlipped it off to that part from which the caterpillar had ſuſpended itſelf. But the pupa has ſtill to diſengage itſelf from this ſmall packet, to which the exuvia is now reduced: here the obſerver will find himſelf intereſted for the little animal, anxious to learn how the pupa will quit this ſkin, and how it will be enabled to fix itſelf to the hillock, as it has neither arms nor legs. A little attention ſoon explains the operation, and extricates the obſerver from his embarraſſment. It ſeizes the exuvia by the rings of the body, and thus holds itſelf as it were by a pair of pincers; then, by bending the tail, it frees itſelf from the old ſkin, and by the ſame method ſoon ſuſpends itſelf to the ſilken mount; it lengthens out the hinder part of the body, and claſps, by means of it's rings, the various foldings of the exuvia one after another; thus creeping backward on the ſpoils, till it can reach the hillock with the tail; which, when examined by the microſcope, will be found to be furniſhed with hooks to fix itſelf by.

It is ſurprizing to ſee with what exactneſs and eaſe theſe inſects perform an operation ſo delicate and dangerous, which is only executed once in their life; and nought elſe can account for it, but the conſideration that he, who deſigned that the caterpillar ſhould paſs through theſe changes, had provided means for that end, regularly connecting the greater ſteps by intermediate ones, the deſire of extending their ſpecies, forming and acting upon the organization, till the purpoſes of their life are completed.

Different kinds of theſe inſects require variety in the mode of ſuſpenſion; ſome fix themſelves in an horizontal poſition, by a girdle which they tie round their body; this girdle appears to the naked eye as a ſingle thread; when examined with the microſcope, it will be found to be an aſſemblage of fine threads, lying cloſe to each other, ſo fixed as to ſupport the caterpillar, and yet leave it in full freedom to effect the changes. Like the preceding kind, it fixes the girdle to the branch of a tree; in this ſituation it remains for ſome time motionleſs, and then begins to bend, move, and agitate it's body in a very ſingular manner, till it has opened the exterior covering, which it puſhes off and removes much in the ſame manner as we have deſcribed in the preceding article, and yet with ſuch dexterity, that the pupa remains ſuſpended by the ſame girdle.

The induſtry of thoſe that ſpin cones, or caſes, in which they incloſe themſelves, in order to prepare for their transformation in ſecurity, is more generally known, as it is from one ſpecies of theſe that we derive ſo many benefits, namely, from the ſilk-worm. All caterpillars undergo ſimilar changes with it, and many in the butterfly ſtate greatly exceed it in beauty: but the golden tiſſue, in which the ſilk-worm wraps itſelf, far ſurpaſſes the ſilky threads of all the other kinds; they may indeed come forth with a variety of colours, and wings bedecked with gold and ſcarlet, yet they are but the beings of a ſummer's day; both their life and beauty quickly vaniſh, and leave no remembrance after them; but the ſilk-worm leaves behind it ſuch beneficial monuments, as at once record the wiſdom of their Creator, and his bounty to man.*

The ſubſtance of which the ſilk is formed, is a fine yellow tranſparent gum, contained in two reſervoirs that wind about the inteſtines, and which, when they are unfolded, are about ten inches long; they terminate in two exceeding ſmall orifices near the mouth, through which the ſilk is drawn, or ſpun, to the degree of fineneſs which it's occaſions may require. This apparatus has been compared to the inſtrument uſed by the wire-drawers,

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* Pullein on the Culture of Silk.

and by which gold and ſilver is drawn to any degree of minuteneſs. Every thread proceeds from theſe two reſervoirs, but are united afterwards; ſo that if it is examined by the microſcope, it will be found to conſiſt of two cylinders, or threads, glued together, with a groove in the middle; a ſeparation may ſometimes be perceived.

When the ſilk-worm has found a convenient ſituation, it ſets to work, firſt ſpinning ſome looſe thread, which ſerves to ſupport the future ſuperſtructure; upon theſe it forms an oval of a looſe texture, conſiſting of what is called the floſs ſilk; within this it forms a firm and more conſiſtent ball of ſilk, remaining during the whole buſineſs within the circumference of the ſpheroid that it is forming, reſting on it's hinder parts, and with it's mouth and fore legs directing and faſtening the threads. Theſe threads are not directed in a regular circular form, but are ſpun in different ſpots, in an infinite number of zig-zag lines: ſo that when it is wound off, it proceeds in a very irregular manner, ſometimes from one ſide of the cone, then from the other. This thread, when meaſured, has been found to be about three hundred yards long, and ſo fine, that eight or ten are generally rolled off into one by the manufacturers. The ſilk-worm uſually employs about three days in finiſhing this cone; the inſide is generally ſmeared with a kind of gum, that is deſigned to keep out the rain; in this cone it aſſumes the pupa form, and remains therein from fifteen to thirty days, according to the warmth of the climate. When the moth is formed, it moiſtens the end of this cone, and by frequent motions of the head looſens the texture of the ſilk, ſo as to form a hole without breaking it.

When the ſilk-worm has attained it's perfect growth, the reſervoirs of ſilk are full, and it is preſſed by it's ſenſations to get rid of this incumbrance, and accordingly ſpins a cone, the altitude and ſize of which are proportioned to it's wants: by traverſing backwards and forwards, it is relieved, and thus attains, by an innate deſire, the end for which it was formed.

The ſize of the cone is not always proportioned to the ſize of the caterpillar; ſome that are ſmall conſtruct larger cones than other caterpillars which are greater in ſize.

There is a caterpillar which forms it's ſilken cone in the ſhape of a boat turned bottom upwards, whence it is called by M. de Reaumur the "coque en batteau;" the conſtruction is complicated, and ſeems to require more art than is uſually attributed to this inſect. It conſiſts of two principal parts, ſhaped like ſhells, which are put together with conſiderable ſkill and propriety; each ſhell, or ſide, is framed by itſelf, and formed of an innumerable quantity of minute ſilk rings; in the fore part there is a projection, in which a ſmall crevice may be perceived, which ſerves, when opened, for the eſcape of the moth; the ſides are connected with ſo much art, that they open and ſhut as if framed with ſprings; ſo that the cone, from which the butterfly has eſcaped, appears as cloſe as that which is ſtill inhabited.

Thoſe which are not furniſhed with a ſilky cone, ſupply their want with various materials, which they are ſufficiently ſkilful to form into a proper habitation, to ſecure them while preparing for the perfect ſtate; ſome conſtruct their's with leaves and branches, tying them faſt together, and then ſtrengthening the connection;

others connect theſe leaves with great regularity; many ſtrip themſelves of their hairs, and form a mixture of hair and ſilk; others conſtruct a cone of ſand, or earth, cementing the particles with a kind of glue; ſome gnaw the wood into a kind of ſaw-duſt, and glue it together; with an innumerable variety of modes ſuited to their preſent and future ſtate.

## OF THE BEETLE.

To make the reader more fully acquainted with a ſubject which affords ſuch abundant matter for the exerciſe of his microſcope, I ſhall proceed to deſcribe, in as conciſe a manner as I am able, the changes of a few inſects of different claſſes, beginning with the beetle.

The beetle is of the firſt (or coleoptrous) claſs, having four wings. The two upper ones are cruſtaceous, and form a caſe to the lower ones; when they are ſhut, there is a longitudinal ſuture down the back: this formation of the wings is neceſſary, as the beetle often lives under the ſurface of the earth, in holes which they dig by their own induſtry and ſtrength. Theſe caſes ſave their real wings from the damage which they might otherwiſe ſuſtain, by rubbing or cruſhing againſt the ſides of their abode; they ſerve alſo to keep the wings clean, and produce a buzzing noiſe when the animal riſes in the air. The ſtrength of the beetle is aſtoniſhing; it has been eſtimated that, bulk for bulk, their muſcles are a thouſand times ſtronger than thoſe of a man.

The beetle is only an inſect diſengaged from the pupa form; the pupa is a transformation in like manner from the worm, or larva, and this proceeds from the egg; ſo that here, as in the foregoing inſtances, one inſect is exhibited in four different ſtates of life, after paſſing through three of which, and the various miſeries attendant on them, it is advanced to a more perfect ſtate. When a larva, it trains a miſerable exiſtence under the earth: in the pupa form it is deprived of motion, and as it were dead. But the beetle itſelf lives at pleaſure above and under ground, and alſo in the air, enjoying a higher degree of life, which it has attained by ſlow progreſſion, and paſſing through difficulties, affliction, and death.

If we judge of the rank which the beetle holds in the ſcale of animation, from the places where they are generally found, from the food which nouriſhes them, from the diſguſting and odious forms of many, from their antipathy to light, and their delight in darkneſs, we ſhall not form great ideas of the dignity of their ſituation. But as all things are rendered ſubſervient to the laws of Divine order, it is ſufficient for us to contemplate the wonders that are diſplayed in this and every other organ of life, for the reception of which, from the FOUNTAIN AND SOURCE OF ALL LIFE, each individual is adapted, and that in a manner correſponding to the ſtate of exiſtence it is to enjoy, and the energies it is called forth to repreſent; indeed the manner of it's exiſtence entirely depends on the degree of life which it is enabled to receive, and the ſtate in which that degree is communicated in it's deſcent through different orders of being.

"One is the flood which univerſal flows;
And hence the reptile, hence the ſeraph glows."

BROOKE.

The egg of the rhinoceros * beetle is of an oblong round figure, of a white colour; the ſhell thin, tender, and flexible; the teeth of the worm that is within the ſhell come to perfection before the other parts; ſo that as ſoon as it is hatched, it is capable of devouring, and nouriſhing itſelf with the wood among which it is placed. The larva, or worm, is curiouſly folded in the egg, the tail reſting between the teeth, which are diſpoſed on each ſide the belly; the worm, in proper time, breaks the ſhell, in the ſame manner as a chicken, and crawls from thence to the next ſuitable ſubſtance.

The worm, when it is hatched, is very white, has ſix legs, a wrinkled naked body, but the other parts all covered with hair: the head is then alſo bigger than the whole body, a circumſtance which may be obſerved in larger animals, and which is founded on wiſe reaſons.† If the egg is obſerved from time to time while the inſect is within it, the beating of the heart may be perceived.

The eggs of the earth-worm, the ſnail, and the beetle, will afford many ſubjects for the microſcope, and will be found to deſerve a very attentive examination. Swammerdam was accuſtomed to hatch them in a diſh, covered with white paper, which he always kept in a moiſt ſtate. To preſerve theſe and ſuch like eggs, they muſt be pierced with a fine needle; the contained liquors muſt be preſſed out, after which they ſhould be blown up by means of a ſmall glaſs tube, and then filled with a little roſin diſſolved in oil of ſpike.

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* Scarabæus Actæon, Lin. Syſt. Nat. p. 541-3.

† Swammerdam's Book of Nature, pt. 1, p. 33.

The worm of the rhinoceros beetle, like other inſects in the larva ſtate, changes it's ſkin; in order to effect which, it diſcharges all it's excrement, and forms a convenient hole in the earth, in which it may perform the wonderful operation; for it does not, like the ſerpent, caſt off merely an external covering, but the throat, a part of the ſtomach, and the inward ſurface of the great gut, change at the ſame time their ſkin: as if it were to increaſe the wonder, and to call forth our attention to theſe repreſentative changes, ſome hundreds of pulmonary pipes caſt alſo each it's delicate ſkin, a tranſparent membrane is taken from the eyes, and the ſkull remains fixed to the exuvia.

After the operation, the head and teeth are white and tender, though at other times as hard as a bone; ſo that the larva, when provoked, will attempt to gnaw iron. For an accurate anatomical deſcription of this worm, I muſt refer the reader to M. Swammerdam; he will find it, like the reſt of this author's works, well worthy of his attentive peruſal. To diſſect it, he firſt killed it in ſpirits of wine, or ſuffocated it in rain water rather more than lukewarm, not taking it out from thence for ſome hours. This preparation prevents an improper contraction of the muſcular fibres.

When the time approaches for the worm to take upon it the pupa form, it generally penetrates deeper into the ground,* or thoſe places where it inhabits, to find a ſituation that it can more eaſily ſuit to it's ſubſequent proceſs. Having found a proper place,

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* The larva of thoſe beetles which live under ground are in general heavy, idle, and voracious; on the contrary, the larva which inhabit the waters are exceedingly active.

place, they form with their hinder feet a poliſhed cavity, in this they lie for ſome time immoveable; after which, by voiding excrementitious ſubſtances, and by the evaporation of humidity, it becomes thinner and ſhorter, the ſkin more furrowed and wrinkled, ſo that it ſoon appears as if it was ſtarved by degrees. If it be diſſected about this period, the head, the belly, and the thorax, may be clearly diſtinguiſhed. While ſome external and internal parts are changing by a ſlow accretion, others are gently diſtended by the force of the blood and impelled humours. The body contracting itſelf, while the blood is propelled towards the fore-parts, forces the ſkull open in three parts, and the ſkin in the middle of the back is ſeparated, by means of an undulating motion of the inciſions of the back; at the ſame time the eyes, the horns, the lips, &c. caſt their exuvia. During this operation, a thin watery humour is diffuſed between the old and new ſkin, which renders the ſeparation eaſier. The proceſs going on gradually, the worm is at laſt diſengaged from it's ſkin, and the limbs and parts are, by a continual unfolding, transformed into the pupa ſtate; after which, it twiſts and compreſſes the exuvia by the fundament, and throws it towards the hinder part under the belly. The pupa is at this time very delicate, tender, and flexible; and affords a moſt aſtoniſhing appearance to an attentive obſerver. Swammerdam thinks it is ſcarce to be equalled among the wonders which are diſplayed in the inſect part of the creation; in it the future parts of the beetle are finely exhibited, ſo diſpoſed and formed, as ſoon to be able to ſerve the creature in a more perfect ſtate of life, and to put on a more elegant form.

The pupa * of this inſect weighs, a little after it's change, much heavier than it does in it's beetle ſtate; this is alſo the caſe with the pupa of the bee and hornet. The latter has been found to weigh ten times as much as the hornet itſelf; this is probably occaſioned by a ſuperabundant degree of moiſture, by which theſe inſects are kept in a ſtate of inactivity (a kind of preternatural dropſy) till it is in ſome meaſure diſſipated; in proportion as this moiſture is evaporated, the ſkin hardens and dries; ſome days are required to ſweat off this ſuperfluous moiſture. If the ſkin is taken off at this time, many curious circumſtances may be noted; but what claims our attention moſt is, that the horn, which is ſo hard in the male beetle when in a ſtate of maturity, that it will bear to be ſharpened againſt a grindſtone, † in the pupa ſtate is quite ſoft, and more like a fluid than a ſolid ſubſtance.

How long the ſcene of mutation continues is not known; ſome remain during the whole winter, more particularly thoſe who quit the larva ſtate in autumn, when a ſudden cold checks their further operations, and conſequently they remain without any food for ſeveral months. Some ſpecies of the beetle tribe go through all the ſtages of their exiſtence in a ſeaſon, while others employ near four years in the proceſs, and live as winged inſects a year.

When the proper time for the final change arrives, all the muſcular parts grow ſtrong, and are thus more able to ſhake off

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* Swammerdam's Book of Nature, p. 144.

† Mouffet, p. 152.

their laſt integuments, which is performed exactly in the ſame manner as in the paſſage of the inſect from the larva to the pupa ſtate, ſo that in this laſt ſkin, which is extremely delicate, the traces of the pulmonary tubes, that have been pulled off and turned out, again become viſible.

All parts of the inſect, and more particularly the wings and their caſes, are at this time ſwelled and extended, by the air and fluids which are driven into them through the arteries and pulmonary tubes; the wings are at this period ſoft as wet paper, and the blood iſſues from them on the leaſt wound; but when they have acquired their proper conſiſtency, which in the elytra is very conſiderable, they will not give the leaſt ſign of any fluid within them, though cut or torn almoſt aſunder.

The pupa being diſengaged from it's ſkin, aſſumes a different form, in which it is dignified with the name of a beetle, with a difference of ſex, being either male or female.

The inſect now begins to enjoy a life far preferable to it's former ſtate of exiſtence; from living in dirt and filth, under briars and thorns, it now raiſes itſelf towards the ſkies, and ſuſtains itſelf with the oozing liquors of flowers.

## OF THE MUSCA CHAMELEON.

We proceed to illuſtrate the nature of the different transformations in inſects, by giving an account of the muſca chameleon: in the worm or larva condition it lives in the water, breathes by the tail, and carries it's legs within a little ſnout near it's mouth.

When it is arrived at the time for it's pupa ſtate, it goes through the change without caſting off the ſkin of the larva. Laſtly, in the imago, or fly ſtate, it would infallibly periſh in the water: the element, which had hitherto ſupplied it with life and motion, would now be it's immediate deſtruction.

This inſect is characterized by Linnæus as muſca chamæleon. Habitat larva in aquis dulcibus; muſca ſupra aquam obambulare ſolet. In a former edition of the Fauna Suecica he called it oeſtrus aquæ; but on a more minute examination, he found it was a muſca; beſides, the larvæ of all known oeſtri are nouriſhed in the bodies of animals.

The larva of this inſect, when viewed by the naked eye, appears to conſiſt of twelve annular diviſions, ſee Plate XI. Fig. 1; by theſe it is ſeparated into a head, thorax, and abdomen; but as the ſtomach and inteſtines lie equally in the thorax and abdomen, it is not eaſy to diſtinguiſh their limits until the inſect approaches the pupa ſtate.

The parts moſt worthy of notice, when this inſect is viewed by the naked eye, are the tail and ſnout. The tail is furniſhed with an elegant crown or circle of hair b, diſpoſed quite round it in an annular form; by means of this the tail is ſupported on the ſurface of the water while the worm or larva is moving therein, the body in the mean while hanging towards the bottom; it will ſometimes remain in this ſituation for a conſiderable time, without the leaſt ſenſible motion. When it has a mind to ſink to the bottom by means of it's tail, it generally bends the hairs of that part towards each other in the middle, but much cloſer towards the

extremity;

extremity; by this means a hollow ſpace is formed, and the bladder of air pent up in it looks like a pearl, Fig. 2, Plate XI. It is by the aſſiſtance of this bubble, or little balloon, that the inſect raiſes itſelf again to the ſurface of the water. If this bubble eſcapes, it can replace it from the pulmonary tubes; ſometimes large quantities of air may be ſeen to ariſe in bubbles from the tail of the worm to the ſurface of the water, and there mix with the incumbent atmoſphere. This operation may be eaſily ſeen by placing the worm in a glaſs full of water, where it will afford a very entertaining ſpectacle.

The ſnout is divided into three parts, of which that in the middle is immoveable; the two other parts grow from the ſides of the former; theſe are moveable, vibrating in a very ſingular manner, like the tongues of lizards and ſerpents. The greateſt ſtrength of the creature is fixed in theſe lateral parts of the ſnout; it is on theſe that it walks when it is out of the water, appearing as it were to walk on it's mouth, uſing it, as the parrot does it's beak, to move (climb) with greater advantage.

We ſhall now conſider the external figure of this worm, as it appears with the microſcope. It is ſmall towards the head, larger about thoſe parts which may be conſidered as the thorax, it then grows ſmaller, converging at the abdomen, terminating in a ſharp tail, ſurrounded with hairs in the form of the rays of a ſtar.

This worm, the head and tail included, has twelve annular diviſions, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, Fig. 3, Plate XI. It's ſkin reſembles the covering of thoſe animals that are provided with a cruſtaceous habit, more than it does that of naked worms or caterpillars; it is moderately hard, and like the rough ſkin called ſhagreen, being thick ſet with a number of grains, evenly diſtributed. The ſubſtance of the ſkin is firm and hard, and yet very flexible.

On each ſide of the body are nine ſpiracula, or holes, for the purpoſe of reſpiration; there are no ſuch holes viſible on the tail ring *a*, nor on the third ring counting from the head; for at the extremity of the tail there is an opening for the admiſſion and expulſion of air: in the third ring the ſpiracula are very ſmall, and appear only under the ſkin, near the place where the embryo wings of the future fly are concealed. It is remarkable that caterpillars, in general, have two rings without theſe ſpiracula; perhaps, becauſe they change into flies with four wings; whereas this worm produces a fly that has only two.

The ſkin has three different ſhades of colour; it is adorned with oblong black furrows, with ſpots of a light colour, and orbicular rings, from which there generally ſprings a hair, as in the figure before us, only the hair that grows on the inſect's ſide is repreſented; beſides this there are here and there ſome other larger hairs c c. The difference of colour in this worm ariſes from the quantity of grains in the ſame ſpace; for in proportion as there is a greater or leſſer quantity of theſe, the furrows and rings are of a deeper or paler colour.

The head *d* is divided into three parts, and covered with a ſkin, the grains on which are hardly diſcernible. The eyes are rather protuberant, and lie forwards near the ſnout. It has alſo two ſmall horns i i on the fore-part of the head. The ſnout is crooked, and ends in a ſharp point as at f; but what is altogether ſingular and ſurprizing, though no doubt wiſely contrived by the great and Almighty Architect, is, that this inſect's legs are placed near the ſnout, between the ſinuſſes, in which the eyes are fixed. Each of theſe legs conſiſts of three joints, the outermoſt of which is covered with hard and ſtiff hairs like briſtles. From the next joint there ſprings a horny bone. h h, which the inſect uſes as a kind of thumb; the joint is alſo of a black ſubſtance, between bone and horn in hardneſs; the third joint is of the ſame nature. To diſtinguiſh theſe particulars, the parts that form the upper ſides of the mouth and the eyes muſt be ſeparated by means of a ſmall fine knife; you may then, by the aſſiſtance of the microſcope, perceive that the leg is articulated by means of ſome particular ligaments, with that portion of the inſect's mouth which anſwers to the lower jaw in the human frame. We may then alſo diſcern the muſcles which ſerve to move the legs, and draw them up into a cavity that lies between the ſnout and thoſe parts of the mouth which are near the horns i i.

This inſect not only walks with theſe legs at the bottom of the water, but even moves itſelf on land by means of them; it likewiſe makes uſe of them to ſwim, while it keeps it's tail on the ſurface contiguous to the air, and hangs downward with the reſt of the body in the water; in this ſituation no motion is perceived in it but what ariſes from it's legs, which it moves in a moſt elegant manner. It is reaſonable to conclude from what has been ſaid, that the principal part of the creature's ſtrength lies in theſe legs: nor will it be difficult for thoſe who are acquainted with the nature of the ancient hieroglyphics (which are now opening ſo clearly)

clearly) to fix the rank of this inſect in animated life, and point out thoſe orders of being, and the moral ſtate through which it receives it's form and habits of life.

The ſnout is black and hard, the back part is quite ſolid, and ſomewhat of a globular form, whereas the front, f, is ſharp and hollow; on the back part three membranaceous diviſions may be obſerved, by means of which, and the muſcles contained in the ſnout, the inſect can at pleaſure expand or contract it.

The tail is conſtructed and planned with great ſkill and wiſdom. The extreme verge, or border, is ſurrounded by thirty hairs, and the ſides adorned with others that are ſmaller; here and there the large hairs branch out into ſmaller ones, which may be reckoned as ſingle hairs. Theſe hairs are all rooted in the outer ſkin, which in this place is covered with rough grains, as may be ſeen by cutting it off, and holding it up, when dry, againſt the light, upon a thin plate of glaſs. By the ſame mode you will find, that at the extremities of the hairs there are alſo grains like thoſe of the ſkin; in the middle of the tail there is a ſmall opening; within it are minute holes, by which the inſect takes in and lets out the air it breathes. The hairs are very ſeldom diſpoſed in ſo regular a manner as they are repreſented in Fig. 3, Plate XI. except when the inſect floats with the body in the water, and the tail with it's hairs a little lower than the ſurface, for they are then diſplayed exactly as delineated in the plate. The leaſt motion downward of the tail produces a concavity in the water, and it then aſſumes the figure of a wine glaſs, wide at the top, narrow at the bottom.

The tail ſerves the larva both for the purpoſes of ſwimming and breathing, and it receives through the tail that which is the univerſal principle of life and motion in animals. By means of theſe hairs it can ſtop itſelf at pleaſure when ſwimming, or remain ſuſpended quietly in the water for any length of time.

The motion of this inſect in ſwimming is very beautiful, eſpecially when it advances with it's whole body floating on the ſurface of the water, after filling itſelf with air by the tail. To ſet out, it firſt bends the body to the right or left, and then contracts it in the form of the letter S, and again ſtretches it out in a ſtrait line: by thus alternately contracting and then extending the body, it moves along on the ſurface of the water. It is of a very quiet diſpoſition, and not diſturbed by handling.

Theſe larva are generally to be found in ſhallow ſtanding waters, about the beginning of June, ſooner or later as the ſummer is more or leſs favorable; in ſome ſeaſons they are to be found in great numbers, while in others it is no eaſy matter to meet with them. They love to crawl on the plants and graſs which grows in the water, and are often to be met with in ditches, floating on the ſurface of the water by means of their tail, the head and thorax at the ſame time hanging down; and in this ſituation they will turn over the clay and dirt with their ſnout and feet in ſearch of food, which is generally a viſcous matter that is common in ſmall ponds and about the ſides of ditches. This worm is very harmleſs, contrary to the opinion one might form at firſt ſight, from the ſurprizing vibratory motion of the legs, which reſembles the brandiſhings of an envenomed tongue or ſting They are moſt eaſily killed for diſſection in ſpirit of turpentine.

After a certain period they paſs into the pupa form; when they are about to change, they betake themſelves to the herbs that float on the ſurface of the water, and creep gently thereon, till at length they lie partly on the dry ſurface, and partly on the water; when in the larva or pupa ſtate, they can live in water, but can by no means inhabit there when changed into flies: indeed, man alſo, whilſt in the uterus, lives in water, which he cannot do afterwards. When theſe worms have found a proper ſituation, they by degrees contract themſelves, and, in a manner ſcarce perceivable, loſe all power of moving. The inward parts of the worm's tail now ſeparate from the outmoſt ſkin, and become greatly contracted; this probably gives the inſect a great deal of pain: by this contraction, an empty ſpace is left in the exterior ſkin, into which the air ſoon penetrates.

Thus this inſect paſſes into the pupa ſtate under it's own ſkin, entirely different from that of the caterpillar, which caſts off the exterior ſkin at this time; this change may often be obſerved to take place in the ſpace of ten or twelve hours, but in what manner it is performed we are ignorant, as it is effected in a hidden unknown way, inwardly within the ſkin, which conceals it from our view.

Whilſt the larva is changing under the ſkin, the body, head, and tail, ſeparate inſenſibly from their outward veſture. The legs at this time, and their cartilaginous bones, are, on account of the parts which are withdrawn from them, left empty; the worm loſes alſo now the former ſkull, the beak, together with the horny bones belonging thereto, which remain in the ſkin of the exuvia. It is worthy of notice, that the optic nerves ſeparate alſo from the eyes, and no more perform their office. The muſcles of the rings alſo in like manner, and a great part of the pulmonary points of reſpiration, are ſeparated from the external ſkin. Thus the whole body contracts itſelf by degrees into a ſmall compact maſs. At this time the gullet and the pulmonary tubes caſt a coat within the ſkin. To make this evident, it is neceſſary to open the abdomen, when the pupa, it's parts, together with the caſt off pulmonary pipes, may be clearly ſeen.

An exact account of all the changes of the interior parts is to be found in Swammerdam's Book of Nature. Theſe changes are beſt examined by taking the pupa out of the ſkin, or outſide caſe, when it begins to harden; for as it has not then quite attained the pupa form, and the members are ſomewhat different from what they will be when in that ſtate, it is more eaſy to obſerve their reſpective ſituation, than when the pupa is ſome days older, and has loſt the greateſt part of the ſuperfluous humours. The pupa is incloſed in a double garment; the interior one is a thin membrane, which inveſts it very cloſely; the other, or exterior one, is formed of the outermoſt hard ſkin of the larva, within which it performs it's changes in an inviſible manner: it is this ſkin which gives it the appearance of the larva while in the pupa ſtate.

When the time approaches that the hidden inſect, now in the pupa form within it's old covering, is to attain the imago, fly, or perfect ſtate, which generally happens in about eleven days after the preceding change, the ſuperfluous humours are evaporated by inſenſible perſpiration. The little pupa is contracted unto the fifth ring of the ſkin, and the four laſt rings of the abdomen are filled with air, through the aperture in the reſpiratory orifice of the tail. This may be ſeen by expoſing the pupa a little while to the rays of the ſun, and then putting it's tail in water, when you will find it breathe ſtronger than it did before, and, by expreſſing an air-bubble out of it's tail, and then ſucking it in again, will manifeſtly perform the action of inſpiration and exſpiration. The anterior part of the pupa is drawn back from the ſkin, and having partly deſerted it, the beak, head, and firſt ring of the breaſt, the little creature lies ſtill, until it's exhaling members have acquired ſtrength to burſt the two membranes which ſurround it.

If the exterior caſe is opened near this period, a wonderful variety of colour may be perceived through the thin ſkin which inveſts the pupa. The colours of many of the different parts are now changed; ſome parts from aqueous become membranaceous, ſome fleſhy, and others cruſtaceous. The whole body becomes inſenſibly ſhaggy, the feet and claws begin to move: the variations may be accurately obſerved by opening a pupa every day until the time of change. For this purpoſe they ſhould be laid on white paper, in an earthen diſh; they ſhould alſo be made ſomewhat moiſt, and be kept under a glaſs: the paper ſerves the pupa to fix it's claw to, when they come forth in the form of a fly. A little water ſhould be poured into the diſh, to keep the pupa from drying and ſuffocation.

When the fly begins to appear, the exterior ſkin is ſeen to move about the third and fourth anterior ring; the inſect then uſes all it's efforts to promote it's eſcape, and to quit the interior and exterior ſkin at one and the ſame time. The exterior ſkin is divided into four parts; the inſect immediately afterwards breaks open it's inner coat, and caſting it off, eſcapes from the priſon in which it was entombed, in the form of a beautiful fly. It is to be obſerved here, that there is nothing accidental in the breaking of the outermoſt ſkin; but it is perfectly ordained by a conſtant order, always happening in the ſame manner in all theſe changes: the ſkin alſo is, in thoſe places where it is broke open, ſo circumſtanced by the Author of nature, as if joined together by ſutures.

When the wings are expanded, the little creature immediately enters into another ſtate of life: for the inſect that lived before in water and mud, now viſits the fields and meadows, being tranſported through the air on it's elegant wings.*

The larva à queue de rat † (muſca pendula, Lin.) is alſo transformed under the ſkin, which hardens, and forms a caſe or general covering to the pupa: two horns are puſhed out, while it is in this ſtate, from the interior parts; they ſerve the purpoſe of reſpiration: this larva will be more particularly deſcribed in a ſubſequent part of this chapter.

The inſects in this claſs, that is, thoſe that paſs into the pupa ſtate under the ſkin of the larva, go through a change more (according to M. de Reaumur) than the caterpillar, undergoing a change while under their ſkin, before they aſſume the pupa form.

The aquatic larva of the muſca chameleon retains it's form to the laſt; but there are many inſects that are transformed under their ſkin, which form a cone or caſe for the pupa. In theſe the larva loſes firſt it's length; the body becoming ſhorter, aſſumes the figure of an egg; and the ſkin forms a hard and cruſtaceous caſe, or ſolid lodging, for the embryo inſect.

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* Swammerdam's Book of Nature, pt. 2, p. 58.

† Reaum. 8vo. edit. tom. 4, pt. 2, 11 mem. p. 199, plate 30 and 31.

## OF THE LIBELLULA.

In the libellula, or dragon fly, we have an inſtance of thoſe inſects who are termed in the pupa ſtate ſemicompleta, that is, who proceed from the egg in the figure which they preſerve, till the time comes of aſſuming their wings, and who walk, act, and eat, as well till that period as afterwards.

Of all the flies which adorn or diverſify the face of nature, there are few, if any, more beautiful than the libellula: "they are almoſt of all colours, green, blue, crimſon, ſcarlet, and white; ſome unite a variety of the moſt vivid tints, and exhibit, in one animal, more different ſhades than are to be found in the rainbow." The larva of the libellula is an inhabitant of the water, the fly itſelf is generally found hovering on the borders thereof.

Theſe inſects are produced from an egg which is depoſited in the water by the parent; the egg ſinks to the bottom, and remains there till the young inſect finds ſtrength to break the ſhell. The larva is hexapode, and is not quite ſo long as the fly; on the trunk are four prominencies, or little bunches, which become more apparent, in proportion as the larva increaſes in ſize and changes it's ſkin. Theſe bunches contain the rudiments of the wings, which adorn the inſect when in it's perfect ſtate.

The head of the larva of this inſect is exceedingly ſingular, being covered with a maſk which goes over the whole fore part of the head, having proper cavities within to ſuit the different prominencies of the face, and fits it more exactly than the common maſk does the human face; it is of a triangular form, growing ſmaller towards the bottom: at the bottom there is a knuckle which fits a cavity near the neck; on this part it turns as on a pivot. The upper part of this maſk is divided into two pieces, or ſhutters, which the inſect can open or cloſe at pleaſure; it can alſo let down the whole maſk whenever it pleaſes. The edges of the ſhutters are toothed like a ſaw. It makes uſe of the maſk to ſeize and hold it's prey.

There is a conſiderable difference in the ſhape of theſe maſks in different ſpecies of the libellula, ſome having two claws near the top of it, which they can throw in or out at pleaſure, and which make it a very formidable inſtrument to the inſects on which it feeds.

Theſe animals generally live and feed at the bottom of the water, ſwimming only occaſionally; their manner of ſwimming, or rather moving in the water, is curious, being by ſudden jerks given at intervals; but this motion is not occaſioned by their legs, which at this time are kept immoveable and cloſe to the body: it is by forcing out a ſtream of water from the tail, that the body is carried forwards; this may be eaſily perceived by placing them in a flat veſſel, in which there is only juſt water enough to cover the bottom. Here the action of the water ſquirted from their tail will be very viſible; it will occaſion a ſmall current, and give a ſenſible motion to any light bodies that are lying on the ſurface thereof. This action can only be effected at intervals, becauſe after each ejaculation the inſect is obliged to take a freſh ſupply of water. The larva will ſometimes turn it's tail above the ſurface of the water, and force out a ſmall ſtream from it, as from a little fountain, and with conſiderable force.

The pupa differs but very little from the larva; the bunches, containing the wings, grow large, and begin to appear like four ſhort thick wings. It is full as lively as the larva, ſeeking and enjoying it's food in the ſame manner: when it is arrived at it's full growth, and is nearly ready to go through it's laſt change, it approaches the edge of the water, or comes entirely out of it, fixing itſelf firmly to ſome piece of wood or other ſubſtance by it's acute claws. It remains for ſome time immoveable; the ſkin then opens down the back, and on the head; through this opening they exhibit the real head and eyes, and at length the legs; it then creeps forward by degrees, drawing it's wings, and then the body, out of the ſkin. The wings, which are moiſt and folded, now expand themſelves to their real ſize; the body is alſo extended till it has gained it's proper dimenſions, which extenſion is accompliſhed by the propelling force of the circulating fluids. When the wings and limbs are dry, it enters on a more noble ſtate of life, it now wings the air and ſeeks it's mate.

——— What terms expreſſive may relate
The change, the ſplendor of their new-form'd ſtate!
In ev'ry eye ten thouſand brilliants blaze,
And living pearls the vaſt horizon gaze;

Gemm'd o'er their heads, the mines of India gleam,
And heaven's own wardrobe has array'd their frame;
Where colours blend an ever-varying dye,
And wanton in their gay exchanges vie.

The females of the gall inſect, which have no wings, paſs through no transformation; while the male, which has two wings, paſſes through the pupa ſtate before it becomes a fly. The only change which takes place in the female gall inſect (and which is, however, a very conſiderable one) is this, that after a certain time it fixes itſelf to the branch of the tree, without being able to detach itſelf; it afterwards increaſes much in ſize, and becomes like a true gall; the female, by remaining thus fixed, for the greater part of her life, to the place where ſhe was firſt ſeen, has very little the appearance of an animal; it is in this period of their life that they grow moſt, and produce their young, while they appear a portion of the branch they adhere to; and what is more ſingular, the larger they grow the leſs they look like animals, and while they are employed in laying thouſands of eggs, one would take them for nothing but mere galls. The genera of gall inſects is very extenſive; they are to be found on almoſt every ſhrub and tree.

The pucerons, to arrive at their perfect ſtate, paſs through that of the ſemicomplete pupa, and their wings do not appear till they have quitted their pupa ſtate; but as in all the families of pucerons there are many who never become winged, we muſt not forget to obſerve, that theſe undergo no transformation, remaining always the ſame, without changing their figure, though they increaſe in ſize, and change their ſkin. It is remarkable, that amongſt inſects of the ſame kind ſome individuals ſhould be transformed, while others are not at all changed: theſe inſects will be conſidered more fully in another part of this chapter.

Mr. Reaumur [*] has ſhewn that the ſpider fly (hyppoboſca equina, Lin.) lays ſo large an egg, that the fly which proceeds from it is as big as the mother, though the egg does not increaſe the leaſt in ſize from the time it is firſt laid. The inſect proceeds alſo from the egg in the imago, or fly ſtate; it is probably transformed in the egg, for Mr. Reaumur has found it in the pupa ſtate therein, and having boiled ſome of their eggs which had been laid for ſome days, he found the inſect in the form of an oval ball, ſimilar to that the pupa of flies with two wings are generally found in. De Geer thinks that the egg itſelf is a true larva, which, when it is born, has nothing elſe to do but to diſengage it's limbs, &c. from the ſhell which covers it; and he thinks this the more probable, becauſe there is no embryo ſeen in this egg, but it is entirely filled with the inſect; he has alſo perceived a contracting and dilating motion in the egg, while it was in the belly of the mother, and immediately after it was lain; circumſtances which do not agree with a ſimple egg.

As Mr. Bonnet [†] has attempted to give a theory of theſe various changes, the following extract from it will, I hope, prove agreeable to the reader; it will at leaſt tend to render his ideas of this wonderful ſubject clearer, and will probably open to his mind many new ſources of contemplation.

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[*] Reaumur, tom. 6, mem. 14.

[†] Bonnet Conſiderations ſur les corps organiſes. Contemplation of Nature, &c.

An inſect that muſt caſt off it's exuvia, or moult five times before it attains the pupa ſtate, may be conſidered as compoſed of five organized bodies, incloſed within each other, and nouriſhed by common viſcera, placed in the center: what the bud of the tree is to the inviſible buds it contains, ſuch is the exterior part of the caterpillar to the interior bodies it conceals in it's boſom.

Four of theſe bodies have the ſame eſſential ſtructure, namely, that which is peculiar to the inſect in it's larva or caterpillar ſtate: the fifth body is that of the pupa. The reſpective ſtate of theſe bodies is in proportion to their diſtance from the center of the animal; thoſe that are fartheſt off have moſt conſiſtence, or unfold themſelves ſooneſt.

When the exterior body has attained it's full growth, that interior one which is next in order is conſiderably unfolded; it is then lodged in too narrow a compaſs, therefore it ſtretches on all ſides the ſheath which covers it; the veſſels which nouriſh the external covering, being broken by this violent diſtenſion, ceaſe to act, the ſkin wrinkles and dries up; at length it opens, and the inſect is cloathed with a new ſkin, and new organs.

The inſect generally faſts for a day or two preceding each change; this is probably occaſioned by the violent ſtate in which it then is, or it may be neceſſary to prevent obſtructions, &c. let this be as it may, the inſect is always very weak after it has changed it's ſkin, the parts being as yet affected by the exertions they have gone through. The ſcaly parts, as the head and legs, are almoſt entirely membranaceous, and imbrued with a fluid that inſinuates itſelf between the two ſkins, and thus facilitates their ſeparation; this moiſture evaporates by degrees, all the parts acquire a conſiſtence, and the inſect is then in a condition to act.

The firſt uſe that ſome caterpillars, who live on leaves, make of their new form, is to devour greedily their exuvia; ſometimes they do not wait till their jaws have acquired their full ſtrength; ſome have been ſeen to gnaw the ſhell from which they proceeded, and even the eggs of ſuch caterpillars as have not been hatched.

When we have once formed the idea that all the exterior parts are inlaid, or included one within the other, the production of new organs does not appear ſo embarraſſing, being nothing more than a ſimple developement; but it is more difficult to form any conception of the changes that happen in the viſcera before and after the transformation, the various modifications they undergo eluding our reſearches. We have already obſerved, that a little before the change the caterpillar rejects the membrane that lines the inteſtinal bag: this bowel has hitherto digeſted only groſs food, whereas it muſt hereafter digeſt that which is very delicate: a fluid that circulates in the caterpillar, from the hind part towards the head, circulates a contrary way after transformation. Now if this inverſion is as real as obſervation ſeems to indicate, how amazing the change the interior parts of the animal muſt have undergone! When the caterpillar moults, ſmall cluſters of the tracheal veſſels are caſt off with the exuvia, and new ones are ſubſtituted in their room; but how is this effected, how are the lungs replaced by other lungs? The more we endeavour to inveſtigate this ſubject, the more we find it is enveloped in darkneſs.

Whilſt the powers of life are employed conformable to the laws of Divine Providence, to change the viſcera, and give them a new form, they are alſo unfolding divers other organs, which were uſeleſs to the inſect while in the larva ſtate, but which are neceſſary to that which ſucceeds. That theſe interior operations of life may be carried on with greater energy, the animal is thrown into a kind of ſleep; during this period, the corpus craſſum is diſtributed into all the parts, in order to bring them to perfection, while the evaporation of the ſuperfluous humours makes way for the elements of the fibres to approach each other, and unite more cloſely. The little wounds in the inſide, which have been occaſioned by the rupture of the veſſels, are gradually conſolidated; thoſe parts which had been violently exerciſed, recover their tone, and the circulating fluids inſenſibly find their new channel. Laſtly, many veſſels are effaced, and turned into a liquid ſediment, which is rejected by the perfect inſect.

When theſe various changes are conſidered, we are ſurprized at the ſingularity of the means the AUTHOR of NATURE has made choice of, in order to bring the different ſpecies of animals to perfection; and are apt to aſk, why the caterpillar was not born a moth? why it paſſes through the larva and pupa ſtate? why all inſects that are transformed do not undergo the ſame change? Theſe, and a variety of queſtions that may be ſtarted concerning the eſſe and eſſence of thoſe exiſtences which appear before us, derive their ſolution from the general ſyſtem which is unknown to us. If all were to arrive at perfection at once, the chain would be broken, the creature unhappy, and man moſt of all.

Amongſt inſects, ſome are produced ſuch as they will be during their whole lives; others come forth incloſed in an egg, and are hatched from this in a form that admits of no variation; many come into the world under a form which differs but little from that which they have when arrived at an age of maturity; ſome again aſſume various forms, that are more or leſs remote from that which conſtitutes their perfect ſtate; laſtly, ſome go through part of theſe transformations in the belly of the mother, and are born of an equal ſize with their parent.

By theſe various changes, a ſingle individual unites within itſelf two or three different ſpecies, and becomes ſucceſſively the inhabitant of two or three worlds: and how great is the diverſity of it's operation in theſe various abodes! Let us alſo conſider what riches we ſhould have been deprived of, if the ſilk-worm had been born in it's perfect ſtate.

Since it has been ſhewn that the larva or caterpillar is really the moth, crawling, eating, and ſpinning, under the form of the worm, and that the pupa is only the moth ſwathed up, it is clear that they are not three ſelfs, or three perſons, but that the ſame individual feels, taſtes, ſees, and acts by different organs, at different periods of it's life, having ſenſations and wants at one time, which it has not at another; theſe wants and ſenſations always bearing a relation to the organs which excite them.

## ON THE RESPIRATION OF INSECTS.

As reſpiration is one of the moſt important actions in the life of every animal, great pains have been taken by many naturaliſts to inveſtigate the nature of this action in inſects; to prove it's exiſtence, and explain in what manner it is carried on. Malphigi, Swammerdam, Reaumur, and Lyonet, have diſcovered in the caterpillar two air-veſſels placed the whole length of the inſect, theſe they have called the tracheæ; they have alſo ſhewn that an infinite number of ramifications proceed from theſe, and are diſperſed through the whole body; that the tracheal veſſels communicate with particular openings on the ſkin of the caterpillar, termed ſpiracula; there are nine of theſe on each ſide of the body. Theſe veſſels ſeem calculated for the reception of air; they contain no fluids, are of a cartilaginous nature, and when cut preſerve their figure, and exhibit a well-terminated opening. Notwithſtanding this diſcovery, the exiſtence of reſpiration has not been proved in many ſpecies of inſects, and the mechaniſm thereof is very obſcure in all; and it is no more ſurprizing, that reſpiration does not exiſt in the embryo ſtate of inſects, than in that of other animals, where we find that reſpiration, which after their birth is abſolutely neceſſary for their exiſtence, to be by no means ſo before it.

M. de Reaumur thought that the air entered by the ſpiracula into the trachea, but did not come out by the ſame orifice, and conſequently that the reſpiration of inſects was carried on in a manner totally different from that of other animals, that the air was exſpired through a number of ſmall holes, or pores, which are to be found in the ſkin of the caterpillar, after having been conducted to them through the extremities of the finer ramifications of the tracheal veſſels: whereas M. Bonnet, in conſequence of a great variety of experiments, ſuppoſed that the inſpiration and exſpiration of the air was through the ſpiracula, and that there was no exſpiration of air through the pores of the ſkin. Theſe experiments were made either by plunging the caterpillars into water, or anointing them with fat and greaſy ſubſtances, ſome all over, others only partially. The number of ſmall bubbles which are obſerved to cover the ſurface of their bodies, when they are immerged in water, does not ariſe from the air which is included within, and then proceeding from them, but they are formed by the air which is lodged near the ſurface of their bodies, in the ſame manner that it is about all other ſubſtances. To render the experiments more accurate, and prevent the air from adhering to the ſkin, before he plunged the caterpillars in water he always bruſhed them over with an hair pencil; after this, very few air bubbles will be found on their bodies when they are immerged in water.

A caterpillar will remain a conſiderable time under water, without deſtroying the principle of life; and they alſo recover, in general, ſoon after they are taken out. To know whether a few only of the ſpiracula might not be ſufficient for the purpoſes of reſpiration, he plunged ſome partially in water, ſo that only two or more ſpiracula remained in the open air: in theſe caſes the caterpillar did not become torpid as it did when they were all immerged in water.

One caterpillar, upon which M. Bonnet made his experiments, lived eight days ſuſpended in water, with only two of it's anterior ſpiracula in the air; during this time he obſerved, that when the inſect moved itſelf, little ſtreams of bubbles iſſued from the anterior ſpiracula on the left ſide; from this and many other experiments it appeared to him, that amongſt all the eighteen ſpiracula, the two anterior and the two poſterior are of the greateſt uſe in reſpiration.* Sometimes, when the mouths of theſe have been ſtopped with oil, the caterpillar has fell into convulſions. If the poſterior part has been oiled, that part will become paralytic. Notwithſtanding theſe experiments, and many more which have been made, the ſubject is far from being decided, and many ſtill doubt whether there is any reſpiration in inſects ſimilar to our's, at leaſt at certain periods of their life.

This opinion ſeems to be further confirmed by the experiments of M. Lyonet. He placed ſeveral of the large muſk beetle, probably the cerambyx moſchatus, under a glaſs, where he had been burning ſulphur, and which he kept burning while they were there; and though the vapour was ſo thick that he could not ſee them, and that he kept them therein more than half an hour, they did not ſeem in the leaſt incommoded.†

When we conſider the great ſolidity of the caſes, or cones, of the pupas of different inſects, it is not eaſy to conceive how they can live ſeveral months under the earth, in ſpaces ſo confined, and almoſt impervious to the air. If reſpiration was abſolutely neceſſary to their exiſtence, and indeed if they did reſpire, the ſame ſituation ſeems to preclude a continuance of the operation, as the air would ſoon be corrupted, and unfit for the offices of life. As the trachea are divided and ſubdivided to a prodigious degree of minuteneſs, it has been conjectured by ſome writers, that they may act as ſo many ſieves, which, by ſeparations properly contrived, filtrate the air, and ſo furniſh it to the body of different degrees of purity and ſubtilty, agreeable to the purpoſes and nature of the various parts. The experiments that have been made with the air-pump are by no means concluſive; the injury the inſect ſuſtains when the atmoſpheric preſſure is taken from the body, does not prove that it inſpired and exſpired the air that we have removed; it only ſhews that an incumbent preſſure is neceſſary to their comfortable exiſtence, as it prevents the fluids from diſengaging themſelves in an aerial form, and as it counterballances and re-acts on the principle of life, and by keeping the action thereof in proper tone and order, confines and regulates it's energies.

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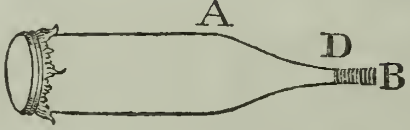
* Philoſ. Tranſ. vol. xlv. p. 300.

† Leſſer Theologie des Inſectes, tom. 1, p. 124. Ibid, p. 126.

Though it is difficult to aſcertain whether ſome inſects reſpire, at leaſt at certain periods of their exiſtence, yet there are others to whom the inſpiration and exſpiration of air ſeems abſolutely neceſſary: there are many aquatic inſects who are obliged to keep their tails ſuſpended on the ſurface of the water for this purpoſe. To prove this, keep the tail under water, and you will perceive the inſect to be agitated and uneaſy, and to ſeek for ſome opening to expoſe this part to the air; if it finds none, it ſoon goes to the bottom and dies. Some aquatic beetles reſiſt the trial for a conſiderable time, while their larva can only ſupport it for a few minutes. There is a circumſtance which renders all experiments on this ſubject with inſects doubtful and difficult, namely, the vaſt tenaciouſneſs of the life principle in the lower orders of animated nature, and it's diſſemination through their whole frame.

M. Muſ-

M. Muſchenbrock incloſed the pupa of a moth in a glaſs tube, nearly of the ſame ſize with the moth itſelf.



The end A of the tube was drawn out into a capillary form, the other end was covered with a piece of wet bladder, to exclude the air; the capillary end was then plunged in water, which roſe to D. He placed the capillary part of the tube before a microſcope, on a ſmall micrometer, in order to obſerve any motion or change in the ſituation of the water; as it is evident the exſpiration or inſpiration of air by the inſect would make it riſe or fall alternately.

In the firſt experiment he obſerved a ſmall degree of motion at diſtant intervals, not above two or three times in an hour; in a ſecond experiment on another ſubject, he could obſerve no motion at all. He then placed ſome pupas under the receiver of an air-pump, in water which he had previouſly purged of it's air; on exhauſting the air from the receiver, he obſerved one bubble to ariſe in a part near the tail, and a few near the wings. The pupa did not ſwell under the operation; on the contrary, on letting in the air, it was found to be diminiſhed in a ſmall degree, but in leſs than a quarter of an hour it recovered it's former figure. Mr. Martinet publiſhed at Leyden, in 1753, a diſſertation, in which, it is ſaid, he has clearly proved, by a number of experiments, that the pupa of the caterpillar and ſome other inſects do not reſpire: I have not ſeen the work.

Among the inſects in which the reſpiration ſeems to be moſt clearly proved, is the larva à queue de rat (muſca pendula, Lin.); theſe live under water in the mud, to which they affix themſelves; though they live under water, the reſpiration of freſh air is neceſſary to their exiſtence; for this purpoſe they are furniſhed with a tail, which often appears of an exceſſive length relative to their body; the body is ſeldom more than three quarters of an inch in length, while the tail is frequently more than four inches; it is compoſed of two tubes, which run one into the other, ſomething ſimilar to the tubes of a refracting teleſcope. Beſides this, the materials of which the tubes are compoſed are capable of a great degree of extenſion. When the tail is at it's full length, it is exceeding ſmall, not being larger near the extremity than a horſe-hair; there is a little knob at the end, which is furniſhed with ſmall hairs, to extend on the water, ſomething ſimilar to thoſe at the tail of the muſca chameleon.

In the body of the larva are two large tracheal veſſels; theſe air-veſſels extend from the head to the tail, and terminate in the reſpiring tubes, and receive the air from them. The larva quits the water when the time of it's transformation approaches, and enters in the earth, where the ſkin hardens and forms a caſe, in which the pupa is formed; ſoon after the change, four tubes, or horns, are ſeen projecting from the caſe: theſe M. de Reaumur ſuppoſes to be organs for communicating air to the interior parts of the inſect; they are connected with little bladders which are found filled with air, and by which it is conveyed to the ſpiracula of the pupa. The larva of gnats, and other ſmall aquatic inſects of the ſame kind, are furniſhed with ſmall tubes, that play on the ſurface of the water, and convey the air from thence to the inſect. Many other ſingularities are to be found among the aquatic larva.

The reader will not, I hope, be diſpleaſed with another account of the muſca pendula, drawn up by a naturaliſt who knew how to render every ſubject intereſting, but more particularly thoſe of this ſcience. "Being out, ſays he, on an excurſion with ſome friends, we were ſtruck with the appearance of a little puddle of reddiſh water, the ſurface of which was in continual motion; on taking up ſome of this water, we found a number of dirty ſhapeleſs animals, which had much the appearance of a common maggot, but much uglier; they were brown, thick, and ſhort, and furniſhed with tails. I ordered them to be laid down on the graſs, and diſpatched a ſervant for ſome clear water, and then began to explain their nature, origin, and properties.

"I had often informed my companions that none of the winged inſects were hatched in their perfect ſtate from the egg, but that they all are firſt produced in the form of worms, maggots, or caterpillars; or, in other words, covered with ſkins, under which they live, move, and eat, and have the appearance of very different animals from their parents; they were not, therefore, ſurprized, when I informed them that the creatures before us were not in their ultimate ſtate, but were the produce of the bee fly, an inſect reſembling the common humble bee in form, ſize, and colour, but having only two wings; whereas the bee has four, and a ſting, which is wanting to the fly.

"This fly is inſtructed by the Univerſal Guide and Guardian of nature, to lay it's eggs about the edges of the water. It's young, while in the worm ſtate, are to live and feed in water; but the female parent cannot depoſit her eggs in that element without periſhing in the attempt. She lays them on dry land, near the proper place of reſidence of her young, and they are inſtructed by the ſame Guide to place them in ſuch a ſituation, that as ſoon as they are hatched they make their way to the water; and finally, when they have acquired their full growth, and the animal within is ready to burſt forth into a new life, and enjoy the regions of the air, it again quits the water, that this great event may be finiſhed at land.

"As the ſervant was now returned with a little water, I juſt obſerved, that though reſpiration is neceſſary to all animal life, yet it is variouſly performed in the ſeveral ſpecies; and that thus, while man and the generality of other animals reſpired by the mouth, this creature does it by the tail. The inſects we were examining were about half an inch long, and their tails near an inch: I proportioned the water in the glaſs to this meaſure in depth, and on our throwing ſome of them into it, their bodies naturally ſunk with the head downwards, and while they ſeemed ſearching after food about the bottom, the extremities of their tails were ſeen juſt above the water, and in continual motion.

"My companions, who have long ſince learnt to make every obſervation of this kind a ſource of adoration to the ſupreme creator, diſpoſer, and preſerver of all things, were admiring the care of his providence in contriving thus amazingly that a poor reptile ſhould not be ſuffocated while it fed. When I ordered a pint more water to be thrown into the glaſs, they all cried out, at firſt, againſt my deſtroying theſe unhappy animals; but their admiration was raiſed much higher than before, when I obſerved that they would receive no harm, for they had a power of lengthening their tail about an inch, but that they were not left without means of life in a much more increaſed depth of water; on adding a quart more water, it was ſoon found that the apparent tail of the inſect was a mere tube, containing within it another much ſmaller, yet ſufficiently large for the paſſage of all the air that was neceſſary to this animal, a fine ſlender pipe being immediately darted up out of this, and extended to the new ſurface; on raiſing the water two inches higher the pipe was immediately lengthened again as far as was neceſſary, and ſo on till the limits of the glaſs ſuffered us to carry the experiment no further."

## OF THE GENERATION OF INSECTS.

One of the greateſt myſteries in nature is generation, or that power by which the various ſpecies of animals, &c. are propagated; by which one ſingle individual gives birth to thouſands, or even millions of individuals like itſelf; all formed agreeable to proportions which are only known to that ADORABLE WISDOM which has eſtabliſhed them. We ſhall never be able to form any adequate conception of this power, till we are acquainted with the principles of life, and can trace their various gradations in different orders of beings. Many ancient philoſophers, from a miſconception and perverſion of the ſentiments of the more ancient ſages, imagined that inſects were produced from corrupt and putrefied ſubſtances; that organized bodies, animated with life, and framed in a moſt wonderful manner, owed their origin to mere chance! Not ſo the moſt ancient ſages; they taught that every degree of life muſt proceed from the fountain and ſource of all life, and that therefore, when manifeſted, it muſt be replete with infinite wonders; but then they alſo ſhewed, that if in it's deſcent through the higher orders of being it was perverted, it would be manifeſted in loathſome forms, and with filthy propenſities; and that according to the degree of reception of the Divine goodneſs and truth, or the perverſion thereof, new forms of life would be occaſionally manifeſted. The gloom of night ſtill wraps this ſubject in obſcurity; will the dawn of day ere long gild the horizon of the ſcientific world? or is the time of it's breaking forth yet far from us? Be this as it may, inſects will be found to conform to that general law of order which runs through the whole of animated nature, namely, that the conjunction of the male and female is neceſſary for the production of their offspring. Where we cannot aſcertain cauſes, we muſt be content with facts.

Though inſects are, like larger animals, diſtinguiſhed into male and female, yet in ſome claſſes there is a kind of mules, partaking of neither ſex, though originating themſelves from the conjunction of both: many other particularities relative to the ſexes can only be touched upon here.

In many inſects the male and female are with difficulty diſtinguiſhed, and in ſome they differ ſo widely, that an unſkilful perſon might eaſily take the male and female of the ſame inſect for different ſpecies; as for inſtance, in the phalæna humuli, piniaria, ruſſula. The diſſimilarity is ſtill greater in thoſe inſects in which the male has wings and the female none, as in the coccus lampyris, phalæna antiqua, &c.

In general the male is ſmaller than the female. The antennæ of the male are, for the moſt part, larger than thoſe of the female. In ſome moths, and other inſects which are furniſhed with feathered antennæ, the feathers of the male fly are large and beautiful, while thoſe of the female are ſmall, and ſcarce to be perceived. Some male beetles are furniſhed with a horn, which is wanting in the female.

"Pleraque inſectorum genitalia ſua intra anum habent abſcondita, et penes ſolitarios, ſed nonnulla penem habent bifidum: cancri autem et aranei geminos, quemadmodum nonnulla amphibia, et quod mirandum in loco alieno, ut cancer, ſub baſi caudæ. Araneus mas palpos habet clavatos, qui penes ſunt, juxta os utrinque unicum, quæ clavæ ſexum nec ſpeciem diſtinguunt; et fœmina vulvas ſuas habet in abdomine juxta pectus; heic vero ſi unquam vere dixeris: res plena timoris amor, ſi enim procus inauſpicato acceſſerit, fœmina ipſum devorat, quod etiam fit, ſi non ſtatim ſe retraxerit. Libellula fœmina genitale ſuum ſub apice gerit caudæ, et mas ſub pectore, adeo ut cum mas collum fœmina forcipe caudæ arripit, illa caudam ſuam pectori ejus adplicet, ſicque peculiari ratione connexæ volitent."

Inſects are either oviparous or viviparous; or, in other words, the ſpecies is perpetuated, either by their laying of eggs, or bringing forth their young alive. The former is the more general caſe; there are but few inſtances of the latter. Thoſe inſects which paſs through the different transformations already deſcribed, cannot propagate till they arrive at their imago or perfect ſtate; and we believe there is ſeldom any conjunction of the ſexes in other claſſes till they have moulted, or put off their laſt ſkin, the cancri and monoculi excepted.

Mr. de Reaumur mentions ſix or ſeven ſpecies of two-winged flies that are viviparous, bringing forth worms, which are afterwards transformed into flies. The womb of one of theſe is ſingularly curious: it is formed of a band rolled up in a ſpiral form, and about two inches and a half in length; ſo that it is ſeven or eight times longer than the body of the fly, and compoſed of worms placed one on the ſide of the other with wonderous art: they are many thouſands in number.*

The habits of the pucerons are ſo very ſingular, that I cannot paſs them over in ſilence; the more ſo, as they are a very curious object for the microſcope. They are called by various names, the proper one is aphis; that which they are moſt known by is puceron, though they are ſometimes called vine fretters and plant lice. They belong to the hemiptera order. The roſtrum is inflected, the antennæ are longer than the thorax, ſome have four erect wings, others have none at all: towards the end of the belly there are two tubes, from which is ejected that moſt delicate juice called honey-dew.

The aphides are a very numerous genus; Linnæus has enumerated thirty-three different ſpecies, whoſe trivial names are taken from the plant which they inhabit, though it is probable the number is much larger, as the ſame plant is often found to ſupport two or three different ſorts of aphides.

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* Reaumur Mem. des Inſectes, tom. 4, p. 415.

An aphis, or puceron, brought up in the moſt perfect ſolitude from the very moment of it's birth, in a few days will be found in the midſt of a numerous family; repeat the experiment on one of the individuals of this family, and you will find this ſecond generation will multiply like it's parent, and this you may purſue through many generations.

Mr. Bonnet had repeated experiments of this kind, as far as the ſixth generation, which all uniformly preſented the obſerver with fruitful virgins, when he was engaged in a ſeries of new and tedious experiments, from a ſuſpicion imparted by Mr. Trembley in a letter to him, who thus expreſſes himſelf: "I have formed "the deſign of rearing ſeveral generations of ſolitary pucerons, in "order to ſee if they would all equally bring forth young. In "caſes ſo remote from uſual circumſtances, it is allowed to try all "ſorts of means; and I argued with myſelf, who knows but that "one copulation might ſerve for ſeveral generations?" This "WHO KNOWS" perſuaded Mr. Bonnet that he had not ſufficiently purſued his inveſtigations. He therefore now reared to the tenth generation his ſolitary aphides, having the patience to keep an exact account of the days and hours of the birth of each generation. He then diſcovered both males and females among them, whoſe amours were not in the leaſt equivocal; the males are produced only in the tenth generation, and are but few in number; that theſe ſoon arriving at their full growth, copulate with the females, and that the virtue of this copulation ſerves for ten ſucceſſive generations; that all theſe generations, except the firſt, from fecundated eggs are produced viviparous, and all the individuals are females, except thoſe of the laſt generation, among whom ſome males appear to lay the foundation of a freſh ſeries.

In order to give a further inſight into the nature of theſe inſects, I ſhall inſert an extract of a deſcription of the different generations of them by Dr. Richardſon, as publiſhed in the Philoſophical Tranſactions, vol. lxi.

The great variety of ſpecies which occur in the inſects now under conſideration, may make an inquiry into their particular natures ſeem not a little perplexing, but by reducing them under their proper genus, the difficulty is conſiderably diminiſhed. We may reaſonably ſuppoſe all the inſects, comprehended under any diſtinct genus, to partake of one general nature; and by diligently examining any particular ſpecies, may thence gain ſome inſight into the nature of all the reſt. With this view Dr. Richardſon choſe out of the various ſorts of aphides the largeſt of thoſe found on the roſe tree; not only as it's ſize makes it the more conſpicuous, but as there are few others of ſo long a duration. This ſort appears early in the ſpring, and continues late in the autumn; while ſeveral are limited to a much ſhorter term, in conformity to the different trees and plants from whence they draw their nouriſhment.

1. If at the beginning of February the weather happens to be ſo warm as to make the buds of the roſe tree ſwell and appear green, ſmall aphides are frequently to be found on them, though not larger than the young ones in ſummer, when firſt produced. It will be found, that thoſe aphides which appear only in ſpring, proceed from ſmall black oval eggs, which were depoſited on the laſt year's ſhoot; though when it happens that the inſects make too early an appearance, the greater part ſuffer from the ſharp weather that uſually ſucceeds; by which means, the roſe trees

are ſome years in a manner freed from them. The ſame kind of animal is then at one time of the year viviparous, and at another oviparous.

Thoſe aphides which withſtand the ſeverity of the weather ſeldom come to their full growth before the month of April, at which time they uſually begin to breed, after twice caſting off their exuvia, or outward covering. It appears that they are all females, which produce each of them a numerous progeny, and that without having intercourſe with any male inſect; they are viviparous, and what is equally ſingular, the young ones all come into the world backwards. When they firſt come from the parent, they are enveloped by a thin membrane, having in this ſituation the appearance of an oval egg; theſe egg-like appearances adhere by one extremity to the mother, while the young ones contained in them extend the other, by that means gradually drawing the ruptured membrane over the head and body to the hind feet. During this operation, and for ſome time after, the fore part of the head adheres, by means of ſomething glutinous, to the vent of the parent. Being thus ſuſpended in the air, it ſoon frees itſelf from the membrane in which it was confined; and after it's limbs are a little ſtrengthened, is ſet down on ſome tender ſhoots, and left to provide for itſelf.

In the ſpring months there appear on the roſe trees but two generations of aphides, including thoſe which proceed immediately from the laſt year's eggs; the warmth of the ſummer adds ſo much to their fertility, that no leſs than five generations ſucceed one another in the interval. One is produced in May, which caſts off it's covering; while the months of June and July each ſupply two more, which caſt off their coverings three or four times, according to the different warmth of the ſeaſon. This frequent change of their outward coat is the more extraordinary, becauſe it is repeated more often when the inſects come the ſooneſt to their growth, which ſometimes happens in ten days, where warmth and plenty of nouriſhment conſpired.

Early in the month of June, ſome of the third generation which were produced about the middle of May, after caſting off their laſt covering, diſcover four erect wings, much longer than their bodies; and the ſame is obſervable in all the ſucceeding generations which are produced during the ſummer months, but ſtill without any diverſity of ſex; for ſome time before the aphides come to their full growth, it is eaſy to diſtinguiſh which will have wings, by a remarkable fullneſs of the breaſt, which in the others is hardly to be diſtinguiſhed from the body. When the laſt covering is rejected, the wings, which were before folded up in a very narrow compaſs, are gradually extended in a very ſurprizing manner, till their dimenſions are at laſt very conſiderable.

The increaſe of theſe inſects in the ſummer time is ſo very great, that by wounding and exhauſting the tender ſhoots they would frequently ſuppreſs all vegetation, had they not many enemies to reſtrain them. Notwithſtanding theſe inſects have a numerous tribe of enemies, they are not without friends, if thoſe may be conſidered as ſuch, who are officious in their attendance for the good things they expect to reap thereby. The ant and the bee are of this kind, collecting the honey in which the aphides abound, but with this difference, that the ants are conſtant viſitors, the bee only when flowers are ſcarce; the ants will ſuck in the honey while the aphides are in the act of diſcharging it; the bees only collect it from the leaves on which it has fallen.

In the autumn three more generations of aphides are produced, two of which generally make their appearance in the month of Auguſt, and the third before the middle of September. The two firſt differ in no reſpect from thoſe which are found in ſummer; but the third differs greatly from all the reſt. Though all the aphides which have hitherto appeared were females, in this tenth generation ſeveral male inſects are found, but not by any means ſo numerous as the females.

The females have at firſt the ſame appearance with thoſe of the former generations, but in a few days their colour changes from a green to a yellow, which is gradually converted into an orange before they come to their full growth; they differ alſo in another reſpect from thoſe which occur in ſummer, for all theſe yellow females are without wings. The male inſects are, however, ſtill more remarkable, their outward appearance readily diſtinguiſhing them from this and all other generations. When firſt produced, they are not of a green colour like the reſt, but of a reddiſh brown, and have afterwards a dark line along the back; they come to their full growth in about three weeks, and then caſt off their laſt covering, the whole inſect being after this of a bright yellow colour, the wings only excepted; but after this change to a deeper yellow, and in a very few hours to a dark brown, if we except the body, which is ſomething lighter coloured, and has a reddiſh caſt. The males no ſooner come to maturity than they copulate with the females, who in a day or two after their intercourſe with the males lay their eggs, generally near the buds.

Where there are a number crowded together, they of courſe interfere with each other, in which caſe they will frequently depoſit their eggs on other parts of the branches.

It is highly probable that the aphides derive conſiderable advantages by living in ſociety; the reiterated punctures of a great number of them may attract a larger quantity of nutritious juices to that part of the tree, or plant, where they have taken up their abode.

In the natural hiſtory of inſects, new objects of ſurprize are continually riſing before the obſerver: ſingular as we have already ſhewn is the production of the puceron, that of the bee will not be found to be leſs ſo; and though this little republic has at all times gained univerſal eſteem and admiration, though they have attracted the attention of the moſt ingenious and laborious inquirers into nature, yet the mode of propagating their ſpecies ſeems to have baffled the ingenuity of ages, and rendered their attempts to diſcover it abortive; even the labours and ſcrupulous attention of Swammerdam were unſucceſsful; though, while he was writing his treatiſe on bees, his daily labour began at ſix in the morning, and from that hour till twelve he continued watching their operations, his head in a manner diſſolving into ſweat, under the irreſiſtible ardour of the ſun; and if he deſiſted at noon, it was only becauſe his eyes then became too weak, as well from the extraordinary afflux of light and the uſe of glaſſes, to continue longer exerciſed by ſuch minute objects. He ſpent one month entirely in examining, deſcribing, and repreſenting their inteſtines; and many months on other parts: employing whole days in making obſervations, and whole nights in regiſtering them, till at laſt he brought his treatiſe of bees to the wiſhed-for perfection, a work which all the ages, from the commencement of natural hiſtory to our own times, have produced nothing to equal, nothing to compare with it.* "Read it, ſays the great Boerhaave, conſider it, and then judge for yourſelf." Reaumur, however, thought he had in ſome meaſure removed the veil, and explained their manner of generating: he ſuppoſes the queen bee to be the only female in the hive, and the mother of the next generation; that the drones are the males, by which ſhe is fecundated; and that the working bees, or thoſe that collect wax on the flowers, that knead it, and form from it the combs and cells, which they afterwards fill with honey, are of neither ſex. The queen bee is known by it's ſize, being generally much larger than the working bee or the drone.

"High on her throne, the bright imperial queen
Gives the prime movement to the ſtate machine:
She in the ſubject ſees the duteous child;
She the true parent, as the regent mild;
With princely grace inveſted ſits elate,
Informs their conduct, and directs the ſtate.
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* * * * * * * *
The cluſtering populace obſequious wait,
Or ſpread the different orders of the ſtate;
Here greet the labourer on the toilſome way,
And to the load their friendly ſhoulders lay;
Or frequent at the buſy gate arrive,
And fill with amber ſweets their fragrant hive;

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* Boerhaave's Life of Swammerdam.

Or ſeek repairs to cloſe the fractur'd cell;
Or ſhut the waxen womb where embryos dwell.
The caterers prompt a frugal portion deal,
And give to diligence a haſty meal;
In each appointed province all proceed,
And neateſt order weds the ſwifteſt ſpeed;
Diſpatch flies various on ten thouſand wings,
And joy throughout the gladſome region rings."

Mr. Schirach, a German naturaliſt, affirms that all the common bees are females in diſguiſe, in which the organs that diſtinguiſh the ſex, and particularly the ovaria, are obliterated, or at leaſt from their extreme minuteneſs have eſcaped the obſerver's eye; that every one of thoſe bees, in the earlier period of it's exiſtence, is capable of becoming a queen bee, if the whole community ſhould think it proper to nurſe it in a particular manner, and raiſe it to that rank: in ſhort, that the queen bee lays only two kinds of eggs, thoſe that are to produce the drones, and thoſe from which the working bees are to proceed.

Mr. Schirach made his experiments not only in the early ſpring months, but even as late as November. He cut off from an old hive a piece of the brood comb, taking care that it contained worms which had been hatched about three days. He fixed this in an empty hive, together with a piece of honey-comb, for food to his bees, and then introduced a number of common bees into the hive. As ſoon as theſe found themſelves deprived of their queen and their liberty, a dreadful uproar took place, which laſted for the ſpace of twenty-four hours. On the ceſſation of this tumult, they betook themſelves to work, firſt proceeding to the conſtruction of a royal cell, and then taking the proper methods for feeding and hatching the brood incloſed with them; ſometimes even on the ſecond day the foundation of one or more royal cells were to be perceived; the view of which furniſhed certain indications that they had elected one of the incloſed worms to the ſovereignty. The bees may now be left at liberty.

The final reſult of theſe experiments is, that the colony of working bees being thus ſhut up with a morſel of brood comb, not only hatch, but at the end of eighteen or twenty days produce from thence one or two queens, which have to all appearance proceeded from worms of the common ſort, which appears to have been converted by them into a queen, merely becauſe they wanted one. *

From experiments of the ſame kind, varied and often repeated, Mr. Shirach concludes that all the common working bees were originally of the female ſex; but that if they are not fed, lodged, and brought up in a particular manner while they are in a larva ſtate, their organs are not developed; and that it is to this circumſtance attending the bringing up of the queen, that the extenſion of the female organs is effected, and the difference in her form and ſize produced.

Mr. Debraw has carried the ſubject further, by diſcovering the impregnation of the eggs by the males, and the difference of the ſize among the drones or males; though indeed this laſt circumſtance was not unknown to Meſſ. Maraldi and Reaumur. Mr. Debraw watched the glaſs hives with indefatigable attention, from

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* Shirach Hiſtoire Naturelle des Abeilles.

from the moment the bees, among which he took care there ſhould be a large number of drones, were put into them ; to the time of the queen's laying her eggs, which generally happens the fourth or fifth day, he obſerved, that on the firſt or ſecond day (always before the third) from the time the eggs are placed in the cells, a great number of bees faſtening themſelves to one another hung down in the form of a curtain, from the top to the bottom of the hive ; they had done the ſame at the time the queen depoſited her eggs, an operation which ſeems contrived on purpoſe to conceal what is tranſacting: however, through ſome parts of this veil he was enabled to ſee ſome of the bees inſerting the poſterior part of their bodies each into a cell, and ſinking into, but continuing there only a little while. When they had retired, it was eaſy to diſcover a whitiſh liquor left in the angle of the baſis of each cell, which contained an egg. In a day or two this liquor was abſorbed into the embryo, which on the fourth day aſſumes it's worm or larva ſtate, to which the working bees bring a little honey for nouriſhment, during the firſt eight or ten days after it's birth. When the bees find the worm has attained it's full growth, they leave off bringing it food, they know it has no more need of it ; they have ſtill, however, another ſervice to pay it, in which they never fail, it is that of ſhutting it up in it's cell, where the larva is incloſed for eight or ten days : here a further change takes place ; the larva, which was heretofore idle, now begins to work, and lines it's cell with fine ſilk, while the working bee incloſes it exteriorly with a wax covering. The concealed larva then voids it's excrement, quits it's ſkin, and aſſumes the pupa ; at the end of ſome days the young bee acquires ſufficient ſtrength to quit the ſlender covering of the pupa, tear the wax covering of it's cell, and proceeds a perfect inſect.

To prove further that the eggs are fecundated by the males, and that their preſence is neceſſary at the time of breeding, Mr. Debraw made the following experiments. They conſiſt in leaving in a hive the queen, with only the common or working bees, without any drones, to ſee whether the eggs ſhe laid would be prolific. To this end, he took a ſwarm, and ſhook all the bees into a tub of water, leaving them there till they were quite ſenſeleſs; by which means he could diſtinguiſh the drones, without any danger of being ſtung: he then reſtored the queen and working bees to their former ſtate, by ſpreading them on a brown paper in the ſun; after this he replaced them in a glaſs hive, where they ſoon began to work as uſual. The queen laid eggs, which, to his great ſurprize, were impregnated; for he imagined he had ſeparated all the drones, or males, and therefore omitted watching them; at the end of twenty days he found ſeveral of his eggs had, in the uſual courſe of changes, produced bees, while ſome had withered away, and others were covered with honey. Hence he inferred, that ſome of the males had eſcaped his notice, and impregnated part of the eggs. To convince himſelf of this, he took away all the brood comb that was in the hive, in order to oblige the bees to provide a freſh quantity, being determined to watch narrowly their motions after new eggs ſhould be laid in the cells. On the ſecond day after the eggs were placed in the cells, he perceived the ſame operation that was mentioned before, namely, that of the bees hanging down in the form of a curtain, while others thruſt the poſterior part of the body into the cells. He then introduced his hand into the hive, broke off a piece of the comb, in which there were two of theſe inſects; he found in neither of them any ſting (a circumſtance peculiar to the drones); upon diſſection, with the aſſiſtance of a microſcope, he diſcovered the four cylindrical bodies which contain the glutinous liquor, of a whitiſh colour, as obſerved by Maraldi in the large drones. He was therefore now under a neceſſity of repeating his experiments, in deſtroying the males, and even thoſe which might be ſuſpected to be ſuch.

He once more immerſed the ſame bees in water, and when they appeared in a ſenſeleſs ſtate, he gently preſſed every one, in order to diſtinguiſh thoſe armed with ſtings from thoſe which had none, and which of courſe he ſuppoſed to be males: of theſe laſt he found fifty-ſeven, and replaced the ſwarm in a glaſs hive, where they immediately applied again to the work of making cells, and on the fourth or fifth day, very early in the morning, he had the pleaſure to ſee the queen bee depoſit her eggs in thoſe cells: he continued watching moſt part of the enſuing days, but could diſcover nothing of what he had ſeen before.

The eggs, after the fourth day, inſtead of changing in the manner of caterpillars, were found in the ſame ſtate they were the firſt day, except that ſome were covered with honey. A ſingular event happened the next day, about noon; all the bees left their own hive, and were ſeen attempting to get into a neighbouring hive, on the ſtool of which the queen was found dead, being no doubt ſlain in the engagement. This event ſeems to have ariſen from the great deſire of perpetuating their ſpecies, and to which end the concurrence of the males ſeems ſo abſolutely neceſſary; it made them deſert their habitation, where no males were left, in order to fix a reſidence in a new one, in which there was a good ſtock of them.

To be further ſatisfied, Mr. Debraw took the brood comb, which had not been impregnated, and divided it into two parts; one he placed under a glaſs bell, No. 1, with honey-comb for the bees food, taking care to leave a queen, but no drones, among the bees confined in it: the other piece of brood-comb he placed under another glaſs bell, No. 2, with a few drones, a queen, and a proportionable number of common bees. The reſult was, that in the glaſs, No. 1, there was no impregnation, the eggs remained in the ſame ſtate they were in when put into the glaſs; and on giving the bees their liberty on the ſeventh day, they all flew away, as was found to be the caſe in the former experiment; whereas in the glaſs, No. 2, the very day after the bees had been put into it, the eggs were impregnated by the drones, and the bees did not leave their hives on receiving their liberty.

The editor of the Cyclopædia ſays, that the ſmall drones are all dead before the end of May, when the larger ſpecies appear, and ſuperſede their uſe; and that it is not without reaſon, that a modern author ſuggeſts that a ſmall number of drones are reſerved, to ſupply the neceſſities of the enſuing year; but that they are very little, if any, larger than the common bee.

It does not enter into our plan to notice further in this place the wonders of this little ſociety. A bee-hive is certainly one of the fineſt objects that can offer itſelf to the eyes of the beholder. It is not eaſy to be weary of contemplating thoſe workſhops, where thouſands of labourers are conſtantly employed in different works. While one party is employed in collecting the matter of the wax, and filling their magazines with it, others work this wax, and build with it their cells; this is again poliſhed and perfected by others: ſome wander abroad to extract the honey from the flower, which they afterwards depoſit in cells, as well for the neceſſities of the day as thoſe of the inclement ſeaſon: ſome cover with wax the cells that contain the honey, which is to be preſerved for the enſuing winter: others feed the young, &c. with various other employments, too numerous to be inſerted here.

The eggs of inſects are contained and arranged in the body of the inſect, in veſſels which vary in number and figure in different ſpecies; the ſame variety is found in the eggs; ſome are round, others oval, ſome cylindrical, and others nearly ſquare; the ſhells of ſome are hard and ſmooth, while others are ſoft and flexible. It is a general rule, that eggs do not increaſe in ſize after they are laid; among inſects we find, however, an exception to this; the eggs of the mouches a ſcie (tenthredo, Linn.) increaſe after they are laid, but their ſhell is ſoft and membranaceous.

The eggs of inſects differ in their colours; ſome may be found of almoſt every ſhade, of yellow, green, brown, and even black. The eggs of the lion puceron * (hemerobius, Linn.) are a very ſingular object, and cannot have eſcaped the eye of any perſon who is converſant among the inſects which live on trees; though of the many who have ſeen them, few, if any, have found what they really were. It is common to ſee on the leaves and pedicles of the leaves of the plumb-tree, and ſeveral other trees, as alſo on their young branches, a number of long and ſlender filaments, running out to about an inch in length; ten or twelve of theſe

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* Reaumur Hiſt. de Inſectes, vol. xi. p. 142.

are uſually ſeen placed near one another, and a vaſt number of theſe cluſters are found on the ſame tree; the end of each of theſe filaments is terminated by a ſort of ſwelling, or tubercle, of the ſhape of an egg. They have generally been ſuppoſed to be of vegetable origin, and that they were a ſort of paraſitical plant, growing out of others. There is a time when theſe egg-like balls, which terminate every one of theſe filaments, are found open at the ends; in this ſtate they very much reſemble flowers, and have been figured as ſuch by ſome authors, though they are only the eggs out of which the young animals had been hatched and made their eſcape. If theſe eggs are examined by a microſcope, a worm may be diſcovered in them; or they may be put in a box, in which, in a proper time, they will produce an inſect, which, when viewed with a microſcope, will be found to be the true lion puceron.

Divine Providence inſtructs the inſects, by a lower ſpecies of perception, to depoſit their eggs in ſituations where their young ones will find the nouriſhment that is moſt convenient for them. Some depoſit their eggs in the oak leaf, producing there the red gall; others chuſe the leaf of the poplar, which ſwells into a red node or bladder; to a ſimilar cauſe we are indebted for the red knob which is often ſeen on the willow-leaf, and the three pointed protuberances upon the termination of the juniper branches. The leaves of the veronica and ceraſtium are drawn into a globular head by the eggs of an inſect lodged therein. The phalæna neuſtria glues it's eggs with great ſymmetry and propriety round the ſmaller branches of trees. Fig. 1, Plate X. repreſents a magnified view of the neſt of the eggs taken off the tree after the caterpillar had eat it's way through them; the ſtrong ground-work of gum, by which they are connected and bound together, is very viſible in many places; they ſtrengthen this connection further, by filling up all the intervening ſpace between the eggs with a very tenacious ſubſtance. The eggs are cruſtaceous, and ſimilar to thoſe of the hen. Fig. 3, Plate X. is a vertical ſection of the eggs, ſhewing their oval ſhape. Fig. 5 is an horizontal ſection through the middle of the egg. It is not eaſy to deſcribe the beauty of theſe objects, when viewed in the lucernal microſcope; the regularity with which they are placed, the delicacy of their texture, the beautiful and ever-varying colours which they preſent to the eye, give the ſpectator a high degree of rational delight.

Some depoſit their eggs in the back of other inſects; theſe, after having paſſed through their various transformations, become what is termed an ichneumon fly. In the Lapland Alps there is a fly covered with a downy hair, called the rhen-deer gad-fly, oeſtrus tarandi, Linn. It hovers all day over theſe animals, whoſe legs tremble under them; they prick up their ears, and flee to the mountains covered with ice and ſnow, to eſcape from a little hovering fly, but generally in vain, for the inſect but too ſoon finds an opportunity to lodge it's egg in the back of the deer; the worm hatched from this egg perforates the ſkin, and remains under it during the whole winter; in the following year it becomes a fly. The oeſtrus bovis is an equal terror to oxen; the hippoboſca equina to horſes; oeſtrus ovis * to the ſheep, &c.

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* Oeſtrus ovis in naſo ſive ſinu frontis animalium rumenantium. Linn.

The gnat, the ephemera, the phryganea, the libellula, hover over the water all day to drop their eggs, which are hatched in the water, and continue there all the time they are in the larva form. The maſs formed by the gnat reſembles a little veſſel ſet afloat by the inſect; each egg is in the form of a keel; theſe are curiouſly connected together. The gnat lays but one egg at a time, which ſhe lays upon the water in a very ingenious and ſimple manner; ſhe ſtretches her legs out, and croſſes them, thus forming an angle to receive and hold the firſt egg; a ſecond egg is ſoon placed next the firſt; then a third, and ſo on, till the baſe is capable of ſupporting itſelf. The ſpawn of this inſect is ſometimes above an inch long, and one-eighth of an inch in diameter, and tied by a little ſtem, or ſtalk, to ſome ſtick or ſtone. Sometimes they are laid in a ſingle, ſometimes in a double ſpiral line; ſometimes tranſverſely. Many moths cover their offspring with a thick bed of hair, which they gather from their own body; while others cover them with a glutinous compoſition, which, when hard, protects them from moiſture, rain, and cold. The gall flies, it has been already obſerved, know how to open the nerves of the leaves, to depoſit thus their eggs in a place which afterwards ſerves them for a lodging, and a magazine of food. The ſolitary bees and waſps prepare an habitation for their little ones in the earth, placing there a proper quantity of food for them, when they proceed from the egg. The voracious and cruel ſpider is attentive and careful of it's eggs; the wolf ſpider carries them on it's back in a little bag formed of it's ſilk; it cannot be ſeparated from them but by violence, and exhibits the moſt marked ſigns of uneaſineſs when deprived of them: a circumſtance the more remarkable, as they love to deſtroy each other, and even carry on their courtſhips with a diffidence and caution unknown in any other ſpecies of animals. The hiſtory of bees and waſps, and their care and attention to their offspring, is ſo well known, that I may with propriety paſs it over here, and proceed juſt to notice the induſtrious ant, whoſe paternal affection and care is not ſo well known. They are not ſatisfied with placing their eggs in ſituations made on purpoſe, and to raiſe or rear them till they come to their nymph or pupa ſtate ; but they even extend their care to the pupa, removing them from their neſt to the ſurface of the earth, whenever the weather is fine, that they may receive the benignant influence of the ſun, carrying them back again as ſoon as the air begins to grow cold. If any accident diſturbs their neſt, and diſperſes the pupas, they manifeſt the greateſt ſigns of diſtreſs, ſeeking the loſt and ſcattered pupas, placing them in ſome ſheltered place while they repair the neſt, when they again tranſport them to it. * Many other curious particulars might be related relative to this induſtrious inſect, as their uniting together in ſcooping out earth, and tranſporting the materials for the conſtruction of their neſts, and the curious ſtructure of the neſt itſelf, which, though it appears piled up at random, will be found, on ſtricter examination, to be a work of art and deſign, with other circumſtances which are too long to be enumerated here.

The perception by which inſects are actuated, ſo as to ſecure in the moſt wonderful manner their offspring, merits the moſt attentive conſideration, and ſtrongly marks the regular proceedings of Divine Providence : they do not depoſit them at random, but place them in ſituations agreeable to their nature, and in places where they will meet with ſuch ſupplies of nouriſhment, as will

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* Leſſers Theologie des Inſectes, tom. 1, p. 143.

will contribute to their perfection, and be acceptable to the ſeveral appetites of their young ones. This is beautifully illuſtrated by Mr. Brooke, in his philoſophical poem on Univerſal Beauty, where, ſpeaking on this ſubject, he ſays,

Each as reflecting on their primal ſtate,
Or fraught with ſcientific craft innate,
With conſcious ſkill their oval embryo ſhed,
Where native firſt their infancy was fed:
Or on ſome vegetating foliage glued;
Or o'er the flood they ſpread their future brood;
A ſlender cord the floating jelly binds,
Eludes the wave, and mocks the warring winds.
O'er this their ſperm in ſpiral order lies,
And pearls in living ranges greet our eyes.
In firmeſt oak they ſcoop a ſpacious tomb,
And lay their embryo in the ſpurious womb:
Some flowers, ſome fruit, ſome gums, or bloſſoms chuſe,
And confident their darling hopes infuſe;
While ſome their eggs in ranker carnage lay,
And to their young adapt the future prey.

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All by their dam's prophetic care receive
Whate'er peculiar indigence can crave:
Profuſe at hand the plenteous tables ſpread,
And various appetites are aptly fed.
No leſs each organ ſuits each place of birth,
Finn'd in the flood, or reptile o'er the earth.

Each organ apt to each precarious ſtate,
As for eternity deſign'd complete.

Of all the productions of nature, inſects are the moſt numerous, and multiply moſt; their fecundity is prodigious, their multiplication aſtoniſhing; the vegetables which cover the ſurface of the earth bear no proportion to their multitudes, every plant ſupporting a number often of ſcarce perceptible creatures; of the fatal effects of their prodigious multiplication, our fruit trees, &c. are too often a deplorable teſtimony. On the continent whole provinces often languiſh in conſequence of the dreadful havock made by the minute, but innumerable, hoſts of inſects.

The following is an experiment of M. Lyonet on the generation of a moth which comes from the chenille a broſſe: out of a brood of 350 eggs, that he had from a ſingle moth of this kind, he took 80, from which he got, when they were arrived at their perfect ſtate, 15 females; from whence he deduces the following conſequence: if 80 eggs give 15 females, the whole brood of 350 would have produced 65; theſe 65, in ſuppoſing them as fertile as their mother, would have produced 22,750 caterpillars, among which there would have been at leaſt 4265 females, who would have produced for the third generation 1,492,750 caterpillars. This number would have been much larger if the number of females among thoſe which were ſelected by M. Lyonet had been greater. M. de Geer counted in the belly of a moth 480 eggs, reducing theſe to 400, if ſuppoſing one-fourth only of theſe to be females, and as fruitful as their mother, they will give birth to 40,000 caterpillars for the ſecond generation; and for the third, ſuppoſing all things equal, four millions of caterpillars. It is not ſurprizing, therefore, that they are found ſo numerous in years which are favorable to their propagation. But the Creator of all things has for our ſakes limited this abundant multiplication, by raiſing up hoſts of enemies, who, beſides ſickneſs, &c. deſtroy the ſuperfluous quantity.

The following is a calculation of the fecundity of the queen bee, by M. de Reaumur: he found that ſhe laid in the two months of March and April 12,000 eggs, ſo that the ſwarm which left the hive in May conſiſted of near 12,000 bees, all produced from one mother; but theſe calculations all fall ſhort of thoſe which were made by Leeuwenhoek on a fly, whoſe larva feeds on fleſh, putrid carcaſes, &c. which multiply prodigiouſly, and that in a ſhort ſpace of time. One of theſe laid 144 eggs, from which he got as many flies in the firſt month; ſo that ſuppoſing one-half of theſe to be females, in the third month we ſhall have 746,496, all produced in three months from one fly.

## Of the Food of Insects.

Inſects feed upon all kinds of vegetable and animal ſubſtances; there is ſcarce any production of theſe two kingdoms which does not ſerve for food to ſome kind of inſect. They may, therefore, be conſidered under two heads, thoſe which live on vegetables, and thoſe which are ſupported by animal food; each inſect knows the food which is proper to ſuſtain it's life, it knows where to ſeek it, and how to procure it. It has been already obſerved, that ſeveral inſects, when arrived at a ſtate of perfection, feed after their transformation upon food totally different from that which nouriſhed them in their larva ſtate; y[illegible] theſe are informed by the laws of Divine order, to place their eggs on ſubjects proper for the larva which are to proceed from them.

Among thoſe which feed on vegetables, ſome ſink themſelves in the earth, deſtroy the roots of the plants, and do conſiderable injuries to our gardens, &c. The food of others is dry and hard; they pierce the wood, reduce it to powder, and then feed on it; ſome, as the coſſus, deſtroy and attack the trees, while the food of others more delicate is the leaves. The leaf is eat in a different manner by different inſects; ſome eat the whole ſubſtance, while others feed only on the parenchemous parts, which are contained between it's ſuperficial membranes, forming within ſide the leaf paths and galleries. Theſe inſects are not always content with the leaf, but attack the flower alſo: even this food is too groſs for many; the bee, the butterfly, the moth, as well as ſeveral ſpecies of flies, feed only on the honey, or finer juices, which they collect from flowers. Fruits, grains, and corn, are not free from them; they divide them with us, and often deprive us of large quantities. We are continually finding the larva of ſome inſect in pears, plumbs, peaches, and other fruit; there is, indeed, no part of a plant which does not ſerve as food to different inſects; ſome have one kind of plant marked out for them to inhabit and feed on, others have another aſſigned to them, on which, and no other, they will feed; each has it's appropriate food, and though the parent animal eats not at all, or lives upon food entirely different, yet ſhe is guided, as we have already obſerved, to depoſit her eggs on that peculiar ſhrub or plant that will be food for her young; while ſome, more voracious than the reſt, feed upon all with equal avidity. The grylus migratorius, a few years ſince, poured out of Tartary in ſuch quantities, as to lay waſte great part of Europe, producing almoſt unequalled calamities, ſwarming in ſuch multitudes as to cloud the air, deſtroying all the vegetables; in Sweden the cattle periſhed with hunger, and the men were forced to abandon their country, and fly to the neighbouring regions.* The far greater part feed only, however, on one ſpecies of plant, or at moſt on thoſe which are ſimilar to it; and the ſame ſpecies may always be found on the ſame plant.

Mr. de Reaumur ſays, that the caterpillar, which infeſts and feeds upon the cabbage, deſtroys in twenty-four hours more than twice it's weight. If larger animals required a proportionable quantity, the earth would not be able to nouriſh it's inhabitants.

A great number of inſects reject vegetable, and live on animal food; ſome ſeeking that which is beginning to putrefy, while others delight in that which is entirely putrid; others again are nouriſhed by the moſt filthy puddles, and diſguſting excrements; ſome attack and feed on man himſelf, while others are nouriſhed by his victuals, his cloaths, his furniture: ſome prey upon inſects of another ſpecies, others attack their own, and harraſs each other with perpetual carnage.

Every animal has it's appropriate lice, which feed on and infeſt it. M. Rhedi has given an accurate account of a great number of theſe little noxious creatures, accompanied with figures; but, as if it were not ſufficient that theſe creatures ſhould dwell and live on the external part of the body, and ſuck the blood of the animal that they infeſt, we find another ſpecies of inſects ſeeking their food in the more vital parts, and feeding on the fleſh of the animal, while full of life and health. M. de Reaumur has given an hiſtory of a fly (oeſtrus bovis) which lives upon the backs, and feeds on the fleſh of young oxen and cows, where it produces a kind of tumor. The fly lodges it's eggs in the fleſh, by making a number of little wounds, in each of which it depoſits eggs, ſo that every wound becomes a neſt, the eggs of which are hatched by the heat of the animal. Here the larva finds abundant food at the ſame time that it is protected from the changes of the weather; and here they ſtay till they are fit for transformation. The parts they inhabit are often eaſy to be diſcovered by a kind of lump, or tumor, which they form by their ravages; this tumor ſuppurates, and is filled with matter; on this diſguſting ſubſtance the larva feeds, and his head is always found plunged in it. When the time of their metamorphoſis is ready, the larva falls upon the ground, and ſeeks a convenient place for the operations of the enſuing change.

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* Select Diſſertations from the Amœnitates Academicæ, vol. 1, p. 398.

There is a ſpecies (oeſtrus hæmorrhoidalis) which depoſit their eggs in the rectum of horſes, it being in the inteſtines of theſe only that they can be nouriſhed. M. Valliſinieri has given an account of the introduction of theſe eggs into the horſe, as obſerved by a friend of his who was looking at ſome that were feeding quietly in a meadow: on a ſudden they began to leap and jump, roll themſelves on the ground, then run, beat about their tails, and were otherwiſe violently agitated; perſuaded that theſe extraordinary motions were produced by a fly that was buzzing about them, he obſerved them narrowly. The fly not being able to ſucceed in it's attacks on theſe, quitted them, and flew towards a mare, who was ſeparated from the reſt, making leſs noiſe than before, and here it was more ſucceſsful; it paſſed under the tail, and by cauſing an itching near the anus, forced the mare to puſh out the edge of the inteſtine, to open it, and then to enlarge the opening; the fly profited by this opportunity, and depoſited it's eggs in the fold of the inteſtine; in a little time the mare became almoſt furious, and was agitated in the moſt violent manner for a quarter of an hour, when ſhe began to grow more eaſy.

Nearly allied to the preceding are the following curious obſervations of an ingenious naturaliſt on the ichneumon fly. "As I was obſerving, ſays he, one day ſome caterpillars which were feeding voluptuouſly on a cabbage-leaf, my attention was attracted towards a part of the plant, about which a little fly was buzzing on it's wing, as if deliberating where to ſettle: I was ſurprized to ſee the herd of caterpillars, creatures of twenty times it's ſize, endeavouring in an uncouth manner, by various contortions of the body, to get out of it's way, and more ſo, whenever the fly poiſed on the wing as if going to drop; at length the creature made it's choice, and ſeated itſelf on the back of one of the largeſt and faireſt of the cluſter; it was in vain the unhappy reptile endeavoured to diſlodge the enemy. If the caterpillar had ſhewn terror on the approach of the fly, it's anguiſh at intervals now ſeemed intolerable, and I ſoon found that it was in conſequence of the ſtrokes, or wounds, given by the fly. At every wound the poor caterpillar wreathed and twiſted it's whole frame, endeavouring to diſengage itſelf, by ſhaking off the enemy, ſometimes aiming it's mouth towards the place; but it was all in vain, it's little but cruel tormentor kept it's place. When it had inflicted thirty or forty of theſe wounds, it took it's flight with a viſible triumph; in each of theſe wounds the little fly had depoſited an egg. I took the caterpillar home with me, to obſerve the progreſs of the eggs which were thus placed in it's body, taking care to give it a freſh ſupply of leaves from time to time; it recovered to all appearance in a few hours from the wounds it had received, and from that time, for the ſpace of four or five days, ſeemed to live comfortably, feeding voraciouſly. The eggs were all hatched into ſmall oblong voracious worms, which fed from the moment of it's appearance on the fleſh of the caterpillar, in whoſe body they were incloſed, and ſeemingly without wounding the organs of reſpiration or digeſtion; and when they had arrived at their full growth, they eat their way out of the ſides of the animal, at the ſame time deſtroying it. The caterpillar thus attacked by the larva of the ichneumon never eſcapes, it's deſtruction is infallible; but then it's life is not taken away at once; the larva, while it is feeding thereon, knows how to ſpare the parts which are eſſential to it's life, becauſe it's own is at that time tied up in that of the caterpillar. No butterfly is produced from it; the worms that feed on the wretched creature are no ſooner out of it's body, than every one ſpins it's own web, and under this they paſs the ſtate of reſt neceſſary to introduce them to their winged form." *

Of this ſtrange ſcene it is difficult for us to form a proper judgment; we are unacquainted with the organs of the caterpillar, ignorant of the nature of it's ſenſations, and therefore we cannot be aſſured what may be the effects of that which we ſee it ſuffer. "It is wiſdom to ſuppoſe we are ignorant, while we know the Creator cannot be cruel." From revelation we learn, that man is

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* Inſpector, No. 64.

is the mean through which life is conveyed to the creatures of this lower world; that by ſinking into error, and foſtering evil, he perverts his own life, and corrupts all that which proceeds from him: ſo that the effects are the ſame on the orders beneath him, as would ariſe to the world if a continual cloud was placed between us and the ſun, depriving us at once of the ſalutary effects of it's invigorating heat and cheering light.

Laſtly, many inſects feed upon others; nay, ſome even upon their own ſpecies. The numbers of theſe two kinds are very numerous; and it is amongſt theſe that we find the traces of the greateſt art and cunning, as well in attack as in defence. Some, indeed, uſe main force alone, others employ addreſs and cunning. Every body is acquainted with the dexterous arts of the ſpider. the curious web he ſpins, it's regular conſtruction, and the central poſition of the ſpider, in order to watch more effectually the leaſt motion that may be communicated to it's tender net. The art and hiſtory of the formica leo are alſo well known, and a deſcription of them would lead us too great lengths. Thoſe who would wiſh to purſue this ſubject further, will find much ſatisfaction in conſulting the works of Reaumur and De Geer.

## OF THE HABITATION OF INSECTS.

Inſects may be divided, with reſpect to their habitations, into two claſſes, aquatic and terreſtrial.

Standing waters are generally filled with inſects, who live therein in different manners. There are, 1. Aquatic inſects which remain always on the ſuperficies of the water, or which at leaſt plunge themſelves therein but rarely. 2. Others that live only in the water, and cannot ſubſiſt out of it. 3. Many, after having lived in the water while in the larva and pupa ſtate, come out afterwards with wings, and become entirely terreſtrial. 4. Some undergo all their transformations in the water, and then become amphibious. 5. Others again are born and grow in the water, but undergo their pupa ſtate on dry land, and after they are arrived at their perfect ſtate live equally in air and water. 6. Laſtly, there are ſome who live at the ſame time part in the water, and part on land, and which after their transformation ceaſe to be aquatic.

Among the inſects which remain on the ſuperficies of the water, are ſome ſpiders, which run with great addreſs and agility, without moiſtening their feet or their body; when they repoſe themſelves, they extend their feet as much as poſſible. There are alſo aquatic bugs, which ſwim, or rather run, on the water with great velocity, and by troops; another bug walks very ſlowly on the water; the gyrinus moves very ſwiftly, and in circles. There is a ſpecies of podura * which live in ſociety, and are often accumulated together in little black lumps. Thoſe inſects which always live in the water are generally born with the figure which they preſerve during their whole lives, as the monoculi, crabs, ſeveral kinds of water-mites, &c.

The number of thoſe which, after having lived in the water, leave it when in a winged ſtate, is very great: among theſe we may reckon the libellula, the ephemera, the phryganea, culices, tipulæ, and ſome ſpecies of muſcæ. All theſe, when in the larva and

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* De Geer Diſcours ſur les Inſectes, tom. 2, p. 103.

and pupa ſtate, live in the water; but when they have aſſumed their perfect form, they are entirely terreſtrial, and would be drowned therein.

The notonecta, the nepa or aquatic ſcorpion, &c. never quit the water till they have paſſed through all their transformations, when they become amphibious, generally quitting it in the evening.

The water-beetles, of which there are many ſpecies, remain in the water all day, but towards evening come upon the ground and fly about, but plunge themſelves again in the water at the approach of the riſing ſun. The larvæ of theſe inſects are entirely aquatic; but when the time of their pupa ſtate arrives, they take to the earth, where they make a ſpherical caſe: ſo that theſe inſects are aquatic as larva, terreſtrial as pupa, and amphibious in the imago ſtate.

We find an inſtance of an inſect that lives at the ſame time in the water and the air, in the ſingular larva deſcribed by M. de Reaumur, Memoires de l'Acad. in 1714, p. 203. It has the head and tail in the water, while the reſt of the body is continually kept above the ſurface. In order to ſupport itſelf in this ſingular poſition, it bends the body, bringing the head near the tail, raiſing the reſt above the water, and ſupporting itſelf againſt ſome fixed object, as a plant, or againſt the borders of the pond; or, if it is placed in a glaſs veſſel, againſt the ſides of the veſſel; and if the glaſs be inclined gently, ſo that the water may nearly cover the larva, it immediately changes it's poſition, in order that part of the body may be kept dry.

At the baths of Abano, a ſmall town in the Venetian ſtate, there is a multitude of ſprings, ſtrongly impregnated with ſulphur, and of a boiling heat. In the midſt of theſe boiling ſprings, within three feet, of four or five of them, there is a tepid one about blood-warm. In theſe waters, not only the common potamogeitous and confervas, or pond-weeds and water-moſſes, are found growing in an healthy ſtate; but numbers of ſmall black water-beetles are ſeen ſwimming about, which die on being taken out and plunged ſuddenly into cold water.*

Many inſects that live under the ſurface of the earth crawl out on certain occaſions, as the julus, ſcolopendra, and the oniſcus; they are alſo often to be found under ſtones, or pieces of rotten wood. Some inſects remain underground part of their life, but quit that ſituation after their change; as do ſome caterpillars, many of the coleoptrous claſs, &c. We have already taken notice that numbers delight to dwell in filth and naſtineſs. The formica leo forms it's habitation in the ſand, as well as many ſpiders; one of theſe forms a hole in the ſand, and then lines it with a kind of ſilk, to prevent it's crumbling away; it generally keeps on the watch near the mouth of the hole, and if it perceives a fly, runs at it with ſuch velocity, as ſeldom to fail in it's attempt of ſeizing it, and then carries it to it's little den.

Another ſpider, diſcovered by Mr. l'Abbé Sauvage,† burrows in the earth like a rabbit, making a hole one or two feet deep, of a regular diameter, and ſufficiently large to move itſelf with eaſe. It lines the whole of it, either to keep the ground from tumbling

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* Jones's Phyſiological Diſquiſitions, p. 171.

† Hiſtoire de l'Acad. 1758, p. 26.

in, or in order to perceive more regularly at the bottom what happens at the mouth, at which it forms a kind of door, made of different layers of earth, connected together by threads, and covered with a ſtrong web of a cloſe texture; the threads are prolonged on one ſide, and fixed to the ground, ſo as to form a ſtrong joint; the door is hung in ſuch a manner, as always to fall by it's own gravity. One of theſe caſes, or neſts, is in her Majeſty's cabinet at Kew.

Inſects are found no where ſo numerous as in trees and plants, where they find abundant food. They dwell 1. in the roots; 2. in the wood; 3. in the leaves, and in the galls which grow upon the leaves and branches; 4. in the flowers; 5. in the fruits and grains. It would be too tedious to enumerate the various ſpecies of theſe inhabitants; many particular obſervations have been already noticed; it has alſo been mentioned, that ſome inhabit the moſt fœtid ſubſtances they can find, while others dwell with and live on the larger animals; ſo that it only remains juſt to mention ſome of thoſe in whom induſtry and art is more ſtrongly marked to our eyes than in others.

Among the ſolitary bees there are ſo many curious circumſtances to be deſcribed, that a ſingle volume would not ſuffice to contain the particulars; we ſhall here only relate ſuch as concern their habitations. One of theſe forms it's neſt under ground, which is compoſed of ſeveral cells artfully let into each other, but not covered with a common incloſure; each cell conſiſts of two or three membranes, inexpreſſibly fine, and placed over each other. The cavity, in which the neſt is placed, is ſmeared over with a layer of matter, like that of which the cells are formed, and apparently ſimilar to that viſcous humour which ſnails ſpread in their paſſage from one place to another, and it is probable that they are formed of the ſame materials; this ſubſtance, though of ſo delicate a nature, gives them ſuch a degree of conſiſtency, that they may be handled without altering their form. An egg is depoſited at the bottom of each cell, where, after it is hatched, the worm finds itſelf in the midſt of a plentiful ſtock of proviſion: for in each cell there is placed a quantity of paſte, or a kind of wax, which is to ſerve as food for the worm, and ſupport the wall of the cell. The worm is alſo inſtructed ſo to conduct itſelf, and eat this food, as to leave ſufficient props for ſupporting the walls of it's apartment.

Many ſpecies of theſe bees content themſelves with penetrating into the earth, ſcooping out hollow cavities therein, poliſhing the walls, then depoſiting an egg and a ſufficient quantity of proviſions.

There is another ſpecies, that forms it's neſt under ground with remarkable induſtry; this bee generally makes a perpendicular hole in the earth about three inches deep, and cylindrical till it comes within about three-fourths of an inch of the bottom, when it begins to open it wider; as ſoon as the bee has given it the ſuitable proportions, it proceeds to line with tapeſtry not only the whole inſide of it's dwelling, but round the entrance: the ſubſtance with which it is lined is of a crimſon colour, and looks like ſattin. From this circumſtance Mr. de Reaumur * terms it the tapeſtry bee. This tapeſtry, or lining, is formed of fragments of the

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* Reaumur Memoires pour l'Hiſtoire des Inſectes, edit. 8vo. tom. 6, partie 1, p. 170.

the flowers of the wild poppy, which ſhe cuts out curiouſly, and then ſeizing them with her legs, conveys them to her neſt. If the pieces are rumpled ſhe ſtraitens them, and then affixes them to her walls with wonderous art; ſhe generally applies two layers of theſe fragments on each other. If the piece ſhe has cut and ranſported is too large for the place ſhe intends it for, ſhe clips off the ſuperfluous parts, and conveys the ſhreds out of the apartment.

After the bee has lined her cell, ſhe fills it nearly half an inch deep with a paſte proper to nouriſh the larva when hatched from the egg; when the bee has amaſſed a ſufficient quantity of paſte, ſhe then takes her tapeſtry, and folds it over the paſte and egg, which are by this means incloſed as it were in a bag of paſte; this done, ſhe fills up with earth the empty ſpace that is above the bag. There is another bee which does the ſame with roſe leaves, and in the ſubſtance of a thick poſt. A friend of mine had a piece of wood cut from a ſtrong poſt that ſupported the roof of a cart-houſe, full of theſe cells or round holes, three-eighths of an inch diameter, and about three-fourths deep, each of which was filled with theſe roſe-leaf caſes, finely covered in at top and bottom.

The maſon bee is ſo called by Reaumur from the manner of it's building it's neſt. Theſe bees collect with their jaws ſmall parcels of earth and ſand, which they glue together with a ſtrong cement, which is furniſhed from the proboſcis; and of this they form a ſimple but commodious habitation, which is generally placed along walls that are expoſed to the ſouth. Each neſt reſembles a lump of rude earth, of about ſix or ſeven inches diameter, thrown againſt the wall; the labour of conſtructing ſo large an edifice muſt be very great, as the bee can only carry a few grains at a time. The exterior form is rude and irregular, but the conſtruction and art exhibited in the interior parts make up for this ſeeming defect; it is generally divided into twelve or fifteen cells, ſeparated from each other by a thick wall; in each of theſe an egg is depoſited by the parent bee. The cells are not conſtructed all at once, for when one is finiſhed ſhe places an egg therein, with a ſufficient quantity of honey to nouriſh the larva; ſhe then builds another. When the inſect is arrived at a proper ſtate, it penetrates through it's incloſures by means of it's ſtrong jaws. When all the bees have quitted the neſt, there are as many holes on the ſurface thereof as there are cells within. We find no neutral bees among this ſpecies, or at leaſt we do not know of any being yet diſcovered.

Another ſpecies of the ſolitary bee (apis centuncularis, Linn.) conſtructs her neſt in pieces of rotten wood, and has therefore been called the carpenter bee.* She divides it into ſtages, diſpoſing them ſometimes in three rows, with partitions curiouſly left between each; in theſe ſhe depoſits her eggs, with the food neceſſary for the young ones when hatched. They ſeparate the wood in a very expeditious manner, by dividing it's ligneous fibres, or threads, till they have made a proper ſized hole.

The art and ſagacity diſplayed by another bee,† whoſe neſt is conſtructed of ſingle pieces of leaves, is truly wonderful. The neſt itſelf is cylindrical, formed of ſeveral cells, placed one within the other as thimbles are in a hardware ſhop. The cells conſiſt of ſeveral pieces cut from one leaf, of forms and proportions proper to coincide with the place each is intended to occupy. The outer caſe, or cover, is formed with equal care and exactneſs. In a word, ſays M. Bonnet, there is ſo much exactneſs, ſymmetry, uniformity, and ſkill, in this little maſter-piece, that we ſhould not believe it to be the work of a fly, if we did not know at what ſchool ſhe learnt the art of conſtructing it. In each cell the mother depoſits an almoſt liquid ſubſtance, and yet ſo nicely are the cells formed, as not to ſuffer any of this ſubſtance to be loſt. But to ſee the detail of the works of this bee, and the curious mechaniſm of it's cells, we muſt refer the reader to Mr. de Reaumur's admirable hiſtory of inſects.

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* Geoffroy Hiſt. abregée des Inſectes, tom. 2, p. 401.

† Reaumur Memoires pour l'Hiſtoire des Inſectes, tom. 6, par. 1, p. 122.

Of the maſon ichneumon waſp * (ſphex, Linn.). The proceedings of this are totally different from thoſe of the common waſp, though equally curious with them. It generally begins it's work in May, and continues at it for the greateſt part of June. The true object of her labour ſeems to be the digging of a hole a few inches deep in the ground; yet in the conſtructing of this ſhe forms a hollow tube above ground, the baſe of which is the opening of the hole, and which it raiſes as high above ground as the hole is deep below; it is formed with a great deal of care, reſembling a groſs kind of fillagree work, conſiſting of the ſand drawn from the hole. The ſand out of which ſhe excavates her cell is nearly as hard as a common ſtone; this it readily ſoftens with a penetrating liquor, with which ſhe is well provided; a drop or two of it is imbibed immediately by the ſand on which it falls, which is inſtantly rendered ſo ſoft, that ſhe can ſeparate and knead

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* Reaumur Mem. pour l'Hiſtoire des Inſectes, tom. xi. par. 2, p. 9.

knead it with her teeth and fore feet, forming it into a ſmall ball, which ſhe places on the edge of the hole as the foundation-ſtone of the pillar ſhe is going to erect: the whole of it is formed of ſuch balls, ranged circularly, and then placed one above the other. She leaves her work at intervals, probably in order to renew her ſtock of that liquor which is ſo neceſſary for her operations; theſe intervals are of ſhort duration; ſhe ſoon returns to her work, and labours with ſo much activity and ardour, that in a few hours ſhe will dig a hole two or three inches deep, and raiſe a hollow pillar two inches high. After the column has been raiſed a certain heighth perpendicularly from the hole, it begins to curve a little, which curvature increaſes till it is finiſhed, though the cylindrical form is maintained: ſhe conſtructs ſeveral of theſe holes all of the ſame form, and for the ſame purpoſe.

It is eaſy to ſee why the hole was dug in the ground; that it was deſtined to receive an egg; but it is not ſo eaſy to perceive why the tube of ſand was formed. By attending to the labours of the waſp, one end, however, may be diſcovered; it will be found to ſerve the purpoſe of a ſcaffold, and that the balls are as uſeful to the waſp, as materials, &c. to the maſon; and are, therefore, placed as much within her reach as poſſible. She uſes them to ſtop and fill up the hole after ſhe has depoſited an egg therein, ſo that the pillar is then deſtroyed, and not the leaſt remains left in the neſt. The parent waſp generally leaves ten or twelve worms as proviſion neceſſary and proper for the growth of the young larva: no purveyor could take better precautions than our waſp, for ſhe has received her inſtructions from HIM who provides for the neceſſities of all his creatures. In ſelecting the worms, ſhe chuſes them of a proper ſize, that they may be ſufficient in quantity, and of an age that will not be in danger of periſhing with hunger, in which caſe they would have been corrupted; ſhe therefore ſelects them when they have their full growth. It is alſo obſerved, that if ſhe chuſes a larger ſort ſhe gives a leſs number of them, and ſo reciprocally.

"By theſe and ſuch like inſtances, every rational mind may confirm itſelf in favour of a Divine agency; for human reaſon, if it be ſo diſpoſed, may collect and be convinced from the various operations in the viſible world, that there is a God, and that he is one; * a truth that is proved by innumerable teſtimonies; for the univerſe is as a theatre, on which the evidence of the exiſtence of a God and his unity are continually exhibited; and from theſe it may be ſeen, that God is the ſole operator by and through nature: for it is clear that nature cannot regard uſes as the ends of her operations, or diſpoſe ſuch uſes into their orders and forms. This is in the power of none but a wiſe being. and of conſequence of none but God, whoſe wiſdom being infinite, can ſo order and form the univerſe, as to make it a coherent and uniform work, all promoting and forming a complex of uſes in orderly arrangement, for the ſervice of man, who is to be a conſtituent of heaven: for the Divine Love cannot deſign any other end beſides the eternal happineſs of the human race, by the communication of itſelf, and the Divine Wiſdom can produce nothing but uſes

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* The ſyſtem one, one Maker ſtands confeſs'd,
The prime, the one, the wond'rous and the bleſs'd,
The one in various forms of unity expreſs'd.

Brooke's Univerſal Beauty, b. iii.

uſes for the promotion of that end. By contemplating the world under this enlarged idea, every wiſe man may diſcern that the Creator of the univerſe is one,* and that his eſſence is love and wiſdom;" and that he effects whatſoever is done in nature, by his own operation, through the medium of the various celeſtial and ſpiritual hierarchies, gradually deſcending from the higheſt orders of this immenſe chain to the loweſt.

Between the loweſt and higheſt degree of corporeal or ſpiritual perfection, there is an almoſt infinite number of intermediate degrees: the reſult of theſe degrees compoſes THE UNIVERSAL CHAIN. This unites all beings, connects all worlds, and comprehends all ſpheres. One SOLE BEING is out of this chain, and that is HE that formed it.† Again, life itſelf, and conſequently the Lord, is the ſupreme, only, and infinite uſe; all other exiſtencies in heaven or earth, whether ſpiritual or natural, are only ultimate effects, or manifeſtations from that one infinite cauſe, exhibiting emblems of the ONE, ETERNAL, INFINITE uſe.

From a retroſpective view of this chapter, we may obſerve a ſtriking difference between man and the lower orders of animal creation. Man is born totally ignorant; ſo much ſo, that he has no knowledge even of the mother's breaſt, till he has been

brought

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* Hence ENDLESS GOOD; hence ENDLESS ORDER ſprings;
Hence that importance in minuteſt things;
And endleſs hence dependence muſt endure,
BLEST IN HIS WILL, and in his power ſecure.

Brooke's Univerſal Beauty, b. vi.

† Bonnet's Contemplation of Nature.

brought acquainted with it by repeated trials; he has no innate ideas, is unable to chuſe what is proper for his food; he cannot form his voice to any articulate pronunciation, or to expreſs the affections of love: whereas, the beaſt, the bird, and the inſect, are born to all that knowledge which is neceſſary for the gratification of thoſe deſires, or that love which forms their life; and conſequently in the knowledge of every thing relating to their well being, their food, their habitations, the commerce of the ſexes, their proviſion for their young, &c.: from the impulſe of the pleaſure ariſing from theſe innate deſires and affections, the larva is alſo prompted to ſeek and aſpire after a change of it's earthly ſtate. If it were not foreign to the ſubject in hand, it might be eaſy to ſhew, by a variety of reaſons, that this imperfection of man at his nativity conſtitutes his real perfection, and places him infinitely, if I may ſo ſpeak, above the brute creation: for man is not created relatively perfect, but formed a recipient of all perfection.

From this view of things, we may, however, perceive that animals are born in order, and conſequently the Divine agency influences or acts on them more immediately. The ſame wiſdom which has conſtructed and arranged their various organs with ſo much art, that they may concur to one determinate end, directs the animal towards this end. Hence it executes with preciſion the works we ſo much admire: hence it ſeems to act as if it was capable of reaſoning. It is excited to all this by that ADORABLE MIND which has traced out to every inſect it's little circle, as he has marked out to each planet it's proper orbit. When, therefore, we ſee an inſect working a neſt, a chryſalis, &c. we ſhould view it with reſpect, becauſe we are beholding a ſcene behind which the SUPREME ARTIST is concealed from our eyes.

We may hence, alſo, perceive that the operations of inſects are the ultimate reſult of the principles of life, upon their organization, which correſponds to the part they are to act in the grand machine of the world; they are, indeed, but ſmall parts, but then theſe parts concur to produce one general effect, by their being interwoven with more important ones; ſo that the thread ſpun by a caterpillar has it's relations to the univerſe as well as the ring of Saturn.* But how immenſe the number of parts, which are interpoſed between this thread and the ring of Saturn, and between SATURN and the worlds of SYRIUS! If the univerſe is one whole, the thread of the caterpillar will alſo be connected with the worlds of Syrius. How great muſt that mind be which can comprehend this immenſe chain of various relations, and can perceive them all to reſolve into UNITY, unity manifeſted in JEHOVAH JESUS! It behoves us to remain in the place that has been allotted for us, from whence we can only diſcover ſome links of the chain. One day we ſhall diſcover more, and ſee things more diſtinctly: mean while we may conſider theſe proceedings of the inſect race, which are ſo diverſified and replete with induſtry, as an agreeable ſpectacle that furniſhes us with an inexhauſtible ſource of real pleaſure, and uſeful inſtruction; that leads us to the Author of the univerſe as it were by the thread of the caterpillar, and which makes us admire in the variety of their means, and in their tendency to the ſame end, the fecundity and wiſdom of the ORDAINING MIND.

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* Bonnet's Contemplation of Nature.

As no inſects exceed the termites in their wonderful œconomy, wiſe contrivances, and ſtupendous buildings, it will be proper to give the reader ſome account of them, which we are enabled to do from the excellent paper deſcribing them, which was written by the late Mr. Smeathman, and publiſhed in the Philoſophical Tranſactions for the year .

The termites are repreſented by Linnæus as the greateſt plagues of both Indies, and are indeed every way between the tropics ſo deemed, from the vaſt damages they cauſe, and the loſſes which are experienced, in conſequence of their eating and perforating wooden buildings, utenſils, furniture, &c. which are totally deſtroyed by them, if not timely prevented; for nothing leſs hard than metal or ſtone can eſcape their moſt deſtructive jaws.

They have been taken notice of by various travellers, in different parts of the torrid zone; and indeed, where numerous, as is the caſe in all equinoctial countries and iſlands that are not fully cultivated, if a perſon has not been incited by curioſity to obſerve them, he muſt have been very fortunate, who, after a ſhort reſidence, has not been compelled to it for the ſafety of his property.

Theſe inſects have generally obtained the name of ants; it may be preſumed, from the ſimilarity in their manner of living, which is in large communities, that erect very extraordinary neſts, for the moſt part on the ſurface of the ground; from whence their excurſions are made through ſubterraneous paſſages, or covered galleries, which they build, whenever neceſſity obliges, or plunder induces them to march above ground, and at a great diſtance from their habitations, carry on a buſineſs of depredation and deſtruction, ſcarce credible but to thoſe who have ſeen it; but notwithſtanding they live in communities, and are like the ants omnivorous, though like them at a certain period they are furniſhed with four wings, and emigrate or colonize at the ſame ſeaſon, they are by no means the ſame kind of inſects, nor does their form correſpond with that of ants in any one ſtate of their exiſtence.

The termites reſemble the ants alſo in their provident and diligent labour, but ſurpaſs them, as well as the bees, waſps, beavers, and all other animals, in the arts of building, as much as the Europeans excel the leaſt cultivated ſavages. It is more than probable they excel them as much in ſagacity, and the arts of government; it is certain they ſhew more ſubſtantial inſtances of their ingenuity and induſtry than any other animals; and do, in fact, lay up vaſt magazines of proviſions and other ſtores; a degree of prudence, which has of late years been denied, perhaps without reaſon, to the ants.

The communities conſiſt of one male and one female, (who are generally the common parents of the whole, or greater part of the reſt) and of three orders of inſects, apparently of very different ſpecies, but really the ſame, which together compoſe great commonwealths, or rather monarchies.

The great Linnæus having ſeen or heard of but two of theſe orders, has claſſed the genus erroneouſly; for he has placed it among the aptera, or inſects without wings; whereas the chief order, that is to ſay, the inſect in it's perfect ſtate, having four wings, without any ſting, it belongs to the neuroptera, in which claſs it will conſtitute a new genus of many ſpecies.

The different ſpecies of this genus reſemble each other in form, in their manner of living, and in their good and bad qualities; but differ as much as birds in the manner of building their habitations or neſts, and in the choice of the materials of which they compoſe them.

There are ſome ſpecies which build upon the ſurface of the ground, or part above, and part beneath; and one or two ſpecies, perhaps more, that build on the ſtem or branches of trees.

Of every ſpecies there are three orders; firſt, the working inſects, which, for brevity, we ſhall generally call labourers; next the fighting ones, or ſoldiers, which do no kind of labour; and laſt of all, the winged ones, or perfect inſects, which are male and female, and capable of propagation: theſe might very appoſitely be called the nobility, or gentry, for they neither labour, nor toil, nor fight, being quite incapable of either, and almoſt of ſelf-defence. Theſe only are capable of being elected kings or queens; and nature has ſo ordered it, that they emigrate within a few weeks after they are elevated to this ſtate, and either eſtabliſh new kingdoms, or periſh within a day or two.

The TERMES BELLICOSUS being the largeſt ſpecies, is moſt remarkable, and beſt known on the coaſt of Africa. It erects immenſe buildings of well-tempered clay, or earth, which are contrived and finiſhed with ſuch art and ingenuity, that we are at a loſs to ſay whether they are moſt to be admired on that account, or for their enormous magnitude and ſolidity.

The reaſon that the larger termites have been moſt remarked is obvious; they not only build larger and more curious neſts, but are alſo more numerous, and do infinitely more miſchief to mankind. When theſe inſects attack ſuch things as we would not wiſh to have injured, we muſt conſider them as moſt pernicious; but when they are employed in deſtroying decayed trees, and ſubſtances which only incumber the ſurface of the earth, they may juſtly be ſuppoſed very uſeful; and for the reaſon that they are in one ſenſe moſt pernicious, they are in the other moſt uſeful. In this reſpect they reſemble very much the common flies, which are regarded by mankind in general as noxious, and at beſt as uſeleſs beings in the creation.

The neſts of this ſpecies are ſo numerous all over the iſland of Bananas, and the adjacent continent of Africa, that it is ſcarce poſſible to ſtand upon any open place, ſuch as a rice plantation, or other clear ſpot, where one of theſe buildings is not to be ſeen almoſt cloſe to each other. In ſome parts near Senegal, as mentioned by M. Adanſon, their number, magnitude, and cloſeneſs of ſituation, make them appear like the villages of the natives.

Theſe buildings are uſually termed hills, by natives as well as ſtrangers, from their outward appearance, which is that of little hills, more or leſs conical, generally very much in the form of ſugar loaves, and about ten or twelve feet in perpendicular height above the common ſurface of the ground.

Theſe hills continue quite bare until they are ſix or eight feet high; but in time the dead barren clay, of which they are compoſed, becomes fertilized by the genial power of the elements in theſe prolific climates, and the addition of vegetable ſalts and other matters brought by the wind; and in the ſecond or third year, the hillock, if not over-ſhaded by trees, becomes like the reſt of the earth, almoſt covered with graſs and other plants; and in the dry ſeaſon, when the herbage is burnt up by the rays of the ſun, it is not much unlike a very large hay-cock.

Every one of theſe buildings conſiſts of two diſtinct parts, the exterior and the interior.

The exterior is one large ſhell, in the manner of a dome, large and ſtrong enough to incloſe and ſhelter the interior from the viciſſitudes of the weather, and the inhabitants from the attacks of natural or accidental enemies. It is always, therefore, much ſtronger than the interior building, which is the habitable part, divided with a wonderful kind of regularity and contrivance into an amazing number of apartments, for the reſidence of the king and queen, and the nurſing of their numerous progeny; or for magazines, which are always found well filled with ſtores and proviſions.

Theſe hills make their firſt appearance above ground by a little turret or two, in the ſhape of ſugar loaves, which are run a foot high, or more; ſoon after, at ſome little diſtance, while the former are increaſing in height and ſize, they raiſe others, and ſo go on increaſing the number, and widening them at the baſe, till their works below are covered with theſe turrets, which they always raiſe the higheſt and largeſt in the middle, and by filling up the intervals between each turret, collect them as it were into one dome.

They are not very curious or exact about theſe turrets, except in making them very ſolid and ſtrong; and when, by the junction of them, the dome is completed, for which purpoſe the turrets anſwer as ſcaffolds, they take away the middle ones entirely, except the tops, (which joined together make the crown of the cupola) and apply the clay to the building of the works within, or to erecting freſh turrets for the purpoſe of raiſing the hillock ſtill higher; ſo that no doubt ſome part of the clay is uſed ſeveral times, like the boards and poſts of a maſon's ſcaffold.

The outward ſhell, or dome, is not only of uſe to protect and ſupport the interior buildings from external violence, and the heavy rains, but to collect and preſerve a regular degree of genial warmth and moiſture, which ſeems very neceſſary for hatching the eggs and cheriſhing the young ones.

The royal chamber, which, on account of it's being adapted for, and occupied by the king and queen, appears to be, in the opinion of this little people, of the moſt conſequence, being always ſituated as near the center of the interior building as poſſible, and generally about the height of the common ſurface of the ground, at a pace or two from the hillock; it is always nearly in the ſhape of half an egg, or an obtuſe oval within, and may be ſuppoſed to repreſent a long oven.

In the infant ſtate of the colony, it is not above an inch, or thereabouts, in length; but in time will be increaſed to ſix or eight inches, or more, in the clear, being always in proportion to the ſize of the queen, who, increaſing in bulk as in age, at length requires a chamber of ſuch dimenſions.

The floor is perfectly horizontal, and in large hillocks, ſometimes an inch thick and upward of ſolid clay; the roof alſo, which is one ſolid and well-turned oval arch, is generally of about the ſame ſolidity, but in ſome places it is not a quarter of an inch thick; this is on the ſides where it joins the floor, and where the doors or entrances are made level therewith, at pretty equal diſtances from each other.

Theſe entrances will not admit any animal larger than the ſoldiers or labourers; ſo that the king, and the queen (who is, when full grown, a thouſand times the weight of a king) can never poſſibly go out.

The royal chamber, if in a large hillock, is ſurrounded by an innumerable quantity of others, of different ſizes, ſhapes, and dimenſions; but all of them arched in one way or another, ſometimes circular, and ſometimes elliptical or oval.

Theſe either open into each other, or communicate by paſſages as wide, and being always empty, are evidently made for the ſoldiers and attendants; of whom, it will ſoon appear, great numbers are neceſſary, and of courſe always in waiting.

Theſe apartments are joined by the magazines and nurſeries; the former are chambers of clay, and are always well filled with proviſions, which to the naked eye ſeem to conſiſt of the raſpings of wood and plants, which the termites deſtroy, but are found in the microſcope to be principally the gums or inſpiſſated juices of plants. Theſe are thrown together in little maſſes, ſome of which are finer than others, and reſemble the ſugar about preſerved fruits; others are like tears of gum, one quite tranſparent, another like amber, a third brown, and a fourth quite opake, as we ſee often in parcels of ordinary gums.

Theſe magazines are intermixed with the nurſeries, which are buildings totally different from the reſt of the apartments; for theſe are compoſed entirely of wooden materials, ſeemingly joined together with gums. They are called nurſeries becauſe they are invariably occupied by the eggs and young ones, which appear at firſt in the ſhape of labourers, but white as ſnow. Theſe buildings are exceedingly compact, and divided into many very ſmall irregular-ſhaped chambers, not one of which is to be found of half an inch in width; they are placed all round the royal apartments, and as near as poſſible to them.

When the neſt is in the infant ſtate, the nurſeries are cloſe to the royal chamber; but as in proceſs of time the queen enlarges, it is neceſſary to enlarge the chamber for her accommodation; and as ſhe then lays a greater number of eggs, and requires a greater number of attendants, ſo it is neceſſary to enlarge and increaſe the number of the adjacent apartments; for which purpoſe, the ſmall nurſeries, which are firſt built, are taken to pieces,

rebuilt

rebuilt a little farther off a ſize bigger, and the number of them increaſed at the ſame time.

Thus they continually enlarge their apartments, pull down, repair, or re-build, according to their wants, with a degree of ſagacity, regularity, and foreſight, not even imitated by any other kind of animals or inſects.

The nurſeries are incloſed in chambers of clay, like thoſe which contain the proviſions, but much larger. In the early ſtate of the neſt they are not bigger than an hazel-nut, but in great hills are often as large as a child's head of a year old.

The diſpoſition of the interior parts of theſe hills is very much alike, except when ſome inſurmountable obſtacle prevents; for inſtance, when the king and queen have been firſt lodged near the foot of a rock, or of a tree, they are certainly built out of the uſual form, otherwiſe pretty nearly according to the following plan.

The royal chamber is ſituated at about a level with the ſurface of the ground, at an equal diſtance from all the ſides of the building, and directly under the apex of the hill. It is on all ſides, both above and below, ſurrounded by what may be called the royal apartments, which have only labourers and ſoldiers in them, and can be intended for no other purpoſe than for theſe to wait in, either to guard or ſerve their common father and mother, on whoſe ſafety depends the happineſs, and, according to the negroes, even the exiſtence of the whole community.

Theſe apartments compoſe an intricate labyrinth, which extends a foot or more in diameter from the royal chamber on every ſide. Here the nurſeries and magazines of proviſions begin, and being ſeparated by ſmall empty chambers and galleries, which go round them, or communicate from one to the other, are continued on all ſides to the outward ſhell, and reach up within it two-thirds or three-fourths of it's height, leaving an open area in the middle under the dome, which very much reſembles the nave of an old cathedral; this is ſurrounded by three or four very large gothic-ſhaped arches, which are ſometimes two or three feet high next the front of the area, but diminiſh very rapidly as they recede from thence, like the arches of aiſles in perſpective, and are ſoon loſt among the innumerable chambers and nurſeries behind them.

All theſe chambers, and the paſſages leading to and from them, being arched, they help to ſupport one another; and while the interior large arches prevent them falling into the center, and keep the area open, the exterior building ſupports them on the outſide.

There are, comparatively ſpeaking, few openings into the great area, and they for the moſt part ſeem intended only to admit that genial warmth into the nurſeries which the dome collects.

The interior building, or aſſemblage of nurſeries, chambers, &c. has a flattiſh top, or roof, without any perforation, which would keep the apartments below dry, in caſe through accident the dome ſhould receive any injury, and let in water; and it is never exactly flat and uniform, becauſe they are always adding to it by building more chambers and nurſeries: ſo that the diviſions, or columns, between the future arched apartments, reſemble the pinnacles upon the fronts of ſome old buildings, and demand particular notice, as affording one proof that for the moſt part the inſects project their arches, and do not make them by excavation.

The area has alſo a flattiſh floor, which lies over the royal chamber, but ſometimes a good height above it, having nurſeries and magazines between. It is likewiſe water-proof, and contrived ſo as to let the water off, if it ſhould get in and run over, by ſome ſhort way, into the ſubterraneous paſſages, which run under the loweſt apartments in the hill, in various directions, and are of an aſtoniſhing ſize, being wider than the bore of a great cannon. There is an account of one that was meaſured, that was perfectly cylindrical, and thirteen inches in diameter.

Theſe ſubterraneous paſſages, or galleries, are lined very thick with the ſame kind of clay of which the hill is compoſed, and aſcend the inſide of the outward ſhell in a ſpiral manner; and winding round the whole building up to the top, interſect each other at different heights, opening either immediately into the dome in various places, and into the interior building, the new turrets, &c. or communicating thereto by other galleries of different bores or diameters, either circular or oval.

From every part of theſe large galleries are various ſmall pipes, or galleries, leading to different parts of the building; under ground there are a great many which lead downward, by ſloping deſcents three and four feet perpendicular among the gravel, from whence the labouring termites cull the finer parts, which being worked up in their mouths to the conſiſtence of mortar, becomes that ſolid clay, or ſtone, of which their hills and all their buildings, except their nurſeries, are compoſed.

Other galleries again aſcend and lead out horizontally on every ſide, and are carried under ground near to the ſurface, a vaſt diſtance: for if you deſtroy all the neſts within one hundred yards of your houſe, the inhabitants of thoſe which are left unmoleſted farther off, will nevertheleſs carry on their ſubterraneous galleries, and invade the goods and merchandizes contained in it by ſap and mine, and do great miſchief if you are not very circumſpect.

But to return to the cities from whence theſe extraordinary expeditions and operations originate, it ſeems there is a degree of neceſſity for the galleries under the hills being thus large, being the great thoroughfares for all the labourers and ſoldiers going forth or returning upon any buſineſs whatever, whether fetching clay, wood, water, or proviſions; and they are certainly well calculated for the purpoſes to which they are applied, by the ſpiral ſlope which is given them; for if they were perpendicular, the labourers would not be able to carry on their building with ſo much facility, as they aſcend a perpendicular with difficulty, and the ſoldiers can ſcarce do it at all. It is on this account that ſometimes a road like a ledge is made on the perpendicular ſide of any part of the building within their hill, which is flat on the upper ſurface, and half an inch wide, and aſcends gradually like a ſtair-caſe, or like thoſe roads which are cut on the ſides of hills and mountains, that would otherwiſe be inacceſſible: by which, and ſimilar contrivances, they travel with great facility to every interior part.

Having given ſome idea of the neſts, we now proceed to give a more particular account of the inſects themſelves, which will be exceedingly neceſſary to a tolerable acquaintance with their œconomy and management, their manner of building, fighting, and marching, and to a more particular account of their uſes in the creation, and of the vaſt miſchief they cauſe to mankind. There are of every ſpecies of termites three orders; of theſe orders the working inſects, or labourers, are always the moſt numerous; in the TERMES BELLICOSUS there ſeem to be at the leaſt one hundred labourers to one of the fighting inſects, or ſoldiers. They are in this ſtate about one-fourth of an inch long, and twenty-five of them weigh about a grain, ſo that they are not ſo large as ſome of our ants; from their external habit and fondneſs for wood, they have been very expreſſively called wood-lice by ſome people, and the whole genus has been known by that name, particularly among the French. They reſemble them, it is true, very much at a diſtance; they run as faſt, or faſter, than any other inſect of their ſize, and are inceſſantly buſtling about their affairs.

The ſecond order, or ſoldiers, have a very different appearance from the labourers, and have been by ſome authors ſuppoſed to be the males, and the former neuters; but they are, in fact, the ſame inſects as the foregoing, only they have undergone a change of form, and approached one degree nearer to the perfect ſtate. They are now much larger, being half an inch long, and equal in bulk to fifteen of the labourers. There is now, likewiſe, a moſt remarkable circumſtance in the form of the head and mouth; for in the former ſtate the mouth is evidently calculated for gnawing and holding bodies; but in this ſtate, the jaws being ſhaped juſt like two very ſharp awls a little jagged, they are incapable of any thing but piercing or wounding, for which purpoſes they are very effectual, being as hard as a crab's claw, and placed in a ſtrong horney head, which is of a nut-brown colour, and larger than all the reſt of the body together, which ſeems to labour under great difficulty in carrying it: on which account, perhaps, the animal is incapable of climbing up perpendicular ſurfaces.

The third order, or the inſect in it's perfect ſtate, varies it's form ſtill more than ever; the head, thorax, and abdomen, differ almoſt entirely from the ſame parts in the labourers and ſoldiers; and beſides this, the animal is now furniſhed with four fine large browniſh tranſparent wings, with which it is, at the time of emigration, to wing it's way in ſearch of a new ſettlement: in ſhort, it differs ſo much from it's form and appearance in the two other ſtates, that it has never been ſuppoſed to be the ſame animal, but by thoſe who have ſeen it in the ſame neſt; and ſome of theſe have diſtruſted the evidence of their ſenſes. It was ſo long before Mr. Smeathman met with them in the neſts, that he doubted the information which was given him by the natives, that they belonged to the ſame family: indeed, you may open twenty neſts without finding one winged one; for thoſe are to be found only juſt before the commencement of the rainy ſeaſon, when they undergo the laſt change, which is preparative to their colonization. Add to this, they ſometimes abandon an outward part of their building, the community being diminiſhed by ſome accident that is unknown; ſometimes different ſpecies of the real ant (formica) poſſeſs themſelves by force of a lodgment, and ſo are frequently diſlodged from the ſame neſt, and taken for the ſame kind of inſects. This is often the caſe with the neſts of the ſmaller ſpecies, which are frequently totally abandoned by the termites, and completely inhabited by different ſpecies of ants, cockroaches, ſcolopendræ, ſcorpions, and other vermin fond of obſcure retreats, that occupy different parts of their roomy buildings.

In the winged ſtate they have alſo much altered their ſize as well as form. Their bodies now meaſure between ſix and ſeven-tenths of an inch in length, and their wings above two inches and a half from tip to tip, and they are equal in bulk to about thirty labourers, or two ſoldiers. They are now alſo furniſhed with two large eyes placed on each ſide of the head, and very conſpicuous; if they have any before, they are not eaſily to be diſtinguiſhed. Probably, in the two firſt ſtates, their eyes, if they have any, may be ſmall like thoſe of moles; for as they live like theſe animals always under ground, they have as little occaſion for theſe organs, and it is not to be wondered at that we do not diſcover them; but the caſe is much altered when they arrive at the winged ſtate, in which they are to roam, though but for a few hours, through the wide air, and explore new and diſtant regions. In this form the animal comes abroad during, or ſoon after, the firſt tornado, which at the latter end of the dry ſeaſon proclaims the approach of the enſuing rains, and ſeldom waits for a ſecond or third ſhower; if the firſt, as is generally the caſe, happens in the night, and brings much wet after it, the quantities that are to be found the next morning all over the ſurface of the earth, but particularly on the waters, is aſtoniſhing; for their wings are only calculated to carry them a few hours; and after the riſing of the ſun, not one in a thouſand is to be found with four wings, unleſs the morning continues rainy, when here and there a ſolitary being is ſeen winging it's way from one place to another, as if ſolicitous only to avoid it's numerous enemies, particularly various ſpecies of ants, which are hunting on every ſpray, on every leaf, and in every poſſible place, for this unhappy race, of which, probably, not a pair in many millions get into a place of ſafety, fulfil the firſt law of nature, and lay the foundation of a new community.

Not only all kinds of ants, birds, and carnivorous reptiles, as well as inſects, are upon the hunt for them, but the inhabitants of many countries eat them.

They are now become, from one of the moſt active, induſtrious, and rapacious, from one of the moſt fierce and implacable little animals in the world, the moſt innocent, helpleſs, and cowardly! never making the leaſt reſiſtance to the ſmalleſt ant. The ants are to be ſeen on every ſide in infinite numbers, of various ſpecies and ſizes, dragging theſe annual victims of the laws of nature to their different neſts. It is wonderful that a pair ſhould ever eſcape ſo many dangers, and get into a place of ſecurity. Some, however, are ſo fortunate; and being found by the labouring inſects that are continually running about the ſurface of the ground under their covered galleries, the little induſtrious creatures immediately incloſe them in a ſmall chamber of clay, ſuitable to their ſize, into which at firſt they leave but one ſmall entrance, large enough for themſelves and the ſoldiers to go in and out, but much too little for either of the royal pair to make uſe of; and when neceſſity obliges them to make more entrances, they are never larger; ſo that, of courſe, the voluntary ſubjects charge themſelves with the taſk of providing for the offspring of their ſovereigns, as well as to work and to fight for them, until they ſhall have raiſed a progeny capable at leaſt of dividing the taſk with them.

The buſineſs of propagation, however, ſoon commences; and the labourers having conſtructed a ſmall wooden nurſery, as before deſcribed, carry the eggs and lodge them there as faſt as they can obtain them from the queen.

About this time a moſt extraordinary change begins to take place in the queen, to which we know nothing ſimilar, except in the PULEX PENETRANS of LINNÆUS, the JIGGER of the Weſt-Indies, and in the different ſpecies of COCCUS COCHINEAL. The abdomen of this female begins gradually to extend and enlarge to ſuch an enormous ſize, that an old queen will have it increaſed ſo as to be fifteen hundred or two thouſand times the bulk of the reſt of her body, and twenty or thirty thouſand times the bulk of a labourer; the ſkin between the ſegments of the abdomen extends in every direction, and at laſt the ſegments are removed to half an inch diſtance from each other, though at firſt the length of the whole abdomen is not above half an inch. They preſerve their dark-brown colour, and the upper part of the abdomen is marked with a regular ſeries of brown bars, from the thorax to the poſterior part of the abdomen, while the intervals between them are covered with a thin, delicate, tranſparent ſkin, and appear of a fine cream colour, a little ſhaded by the dark colour of the inteſtines and watery fluid ſeen here and there beneath. It is ſuppoſed that the animal is upwards of two years old when the abdomen is increaſed to three inches in length: they have ſometimes been found of near twice that ſize. The abdomen is now of an irregular oblong ſhape, being contracted by the muſcles of every ſegment, and is become one vaſt matrix full of eggs, which make long circumvolutions through an innumerable quantity of very minute veſſels, that circulate round the inſide in a ſerpentine manner, which would exerciſe the ingenuity of a ſkilful anatomiſt to diſſect and develope. This ſingular matrix is not more remarkable for it's amazing extenſion and ſize, than for it's periſtaltic motion, which reſembles the undulating of waves, and continues inceſſantly without any apparent effort of the animal; ſo that one part or other alternately is riſing and ſinking in perpetual ſucceſſion, and the matrix ſeems never at reſt, but is always protruding eggs to the amount, as have been frequently counted in old queens, of ſixty in a minute, or eighty thouſand and upwards in one day of twenty-four hours.

Theſe eggs are inſtantly taken from her body by her attendants, (of whom there always are, in the royal chamber and galleries adjacent, a ſufficient number in waiting) and carried to the nurſeries, which in a great neſt may ſome of them be four or five feet diſtant in a ſtrait line, and conſequently much farther by their winding galleries. Here, after they are hatched, the young are attended and provided with every thing neceſſary, until they are able to ſhift for themſelves, and take their ſhare of the labours of the community. The foregoing is an accurate deſcription and account of the termes bellicoſus, or ſpecies that builds the large neſts, in it's different ſtates.

Thoſe which build either the roofed turrets, or the neſts in the trees, ſeem, in moſt inſtances, to have a ſtrong reſemblance to them, both in their form and œconomy, going through the ſame changes from the egg to the winged ſtate. The queens alſo increaſe to a great ſize when compared with the labourers, but very ſhort of thoſe queens before deſcribed. The largeſt are from about an inch to an inch and a half long, and not much thicker than a common quill. There is the ſame kind of periſtaltic motion in the abdomen, but in a much ſmaller degree; and as the animal is incapable of moving from her place, the eggs, no doubt, are carried to the different cells by the labourers, and reared with a care ſimilar to that which is practiſed in the larger neſts.

It is remarkable of all theſe different ſpecies, that the working and the fighting inſects never expoſe themſelves to the open air, but either travel under ground, or within ſuch trees and ſubſtances as they deſtroy; except, indeed, when they cannot proceed by their latent paſſages, and find it convenient or neceſſary to ſearch for plunder above ground: in that caſe they make pipes of that material with which they build their neſts. The larger ſort uſe the red clay; the turret builders uſe the black clay; and thoſe which build in the trees employ the ſame ligneous ſubſtance of which their neſts are compoſed.

The termites, except their heads, are exceedingly ſoft, and covered with a very thin and delicate ſkin; being blind, they are no match on open ground for the ants, who can ſee, and are all of them covered with a ſtrong horny ſhell not eaſily pierced, and are of diſpoſitions bold, active, and rapacious.

Whenever the termites are diſlodged from their covered ways, the various ſpecies of the former, who probably are as numerous above ground as the latter are in their ſubterraneous paſſages, inſtantly ſeize and drag them away to their neſts, to feed the young brood. The termites are, therefore, exceedingly ſolicitous about the preſerving their covered ways in good repair; and if you demoliſh one of them for a few inches in length, it is wonderful how ſoon they rebuild it. At firſt, in their hurry, they get into the open part an inch or two, but ſtop ſo ſuddenly, that it is very apparent they are ſurprized: for though ſome run ſtrait on, and get under the arch as ſpeedily as poſſible in the further part, moſt of them run as faſt back, and very few will venture through that part of the track which is left uncovered. In a few minutes you will perceive them re-building the arch, and by the next morning they will have reſtored their gallery for three or four yards in length, if ſo much has been ruined; and upon opening it again, will be found as numerous as ever under it, paſſing both ways. If you continue to deſtroy it ſeveral times, they will at length ſeem to give up the point, and build another in a different direction; but if the old one led to ſome favourite plunder, in a few days will rebuild it again; and, unleſs you deſtroy their neſt, never totally abandon their gallery. They do conſiderable damage to houſes, &c. They make their approaches chiefly under ground, deſcending below the foundations of houſes and ſtores at ſeveral feet from the ſurface, and riſing again either in the floors, or entering at the bottom of the poſts, of which the ſides of the buildings are compoſed, bore quite through them, following the courſe of the fibres to the top, or making lateral perforations and cavities here and there as they proceed.

While ſome are employed in gutting the poſts, others aſcend from them, entering a rafter, or ſome other part of the roof. If they once find the thatch, which ſeems to be a favourite food, they ſoon bring up wet clay, and build their pipes, or galleries, through the roof in various directions, as long as it will ſupport them; ſometimes eating the palm-tree leaves and branches of which it is compoſed, and perhaps (for variety ſeems very pleaſing to them) the rattan, or other running plant, which is uſed as a cord to tie the various parts of the roof together, and that to the poſts which ſupport it. Thus, with the aſſiſtance of the rats, who, during the rainy ſeaſon, are apt to ſhelter themſelves there, and to burrow through it, they very ſoon ruin the houſe, by weakening the faſtenings and expoſing it to the wet. In the mean time, the poſts will be perforated in every direction, as full of holes as that timber in the bottoms of ſhips, which has been bored by the worms; the fibrous and knotty parts, which are the hardeſt, being left to the laſt.

Theſe inſects are not leſs expeditious in deſtroying the ſhelves, wainſcotting, and other fixtures of an houſe, than the houſe itſelf. They are continually piercing and boring in all directions, and ſometimes go out of the broadſide of one poſt into that of another adjoining to it; but they prefer and always deſtroy the ſofter ſubſtances the firſt, and are particularly fond of pine and fir-boards, which they excavate and carry away with wonderful diſpatch and aſtoniſhing cunning: for, except a ſhelf has ſomething ſtanding upon it, as a book, or any thing elſe which may tempt them, they will not perforate the ſurface, but artfully preſerve it quite whole, and eat away all the inſide, except a few fibres, which barely keep the two ſides connected together; ſo that a piece of an inch-board, which appears ſolid to the eye, will not weigh much more than two ſheets of paſteboard of equal dimenſions, after theſe animals have been a little while in poſſeſſion of it. In ſhort, the termites are ſo inſidious in their attacks, that we cannot be too much on our guard againſt them: they will ſometimes begin and raiſe their works, eſpecially in new houſes, through the floor. If you deſtroy the work ſo begun, and make a fire upon the ſpot, the next night they will attempt to riſe through another part; and if they happen to emerge under a cheſt, or trunk, early in the night will pierce the bottom, and deſtroy or ſpoil every thing in it before the morning. On theſe accounts the inhabitants ſet all their cheſts and boxes upon ſtones or bricks, ſo as to leave the bottoms of ſuch furniture ſome inches above the ground, which not only prevents theſe inſects finding them out ſo readily, but preſerves the bottoms from a corroſive damp, which would ſtrike from the earth through, and rot every thing therein: a vaſt deal of vermin alſo would harbour under, ſuch as cockroaches, centipedes, millepedes, ſcorpions, ants, and various other noiſome inſects.

Though the view we have given of the various proceedings of inſects in forming their habitations, has already run to ſome length, we cannot with propriety neglect taking ſome further notice of the wonderful induſtry and art which is manifeſted in theſe reſpects by the caterpillar; and more particularly ſo, as it is by it we obtained the foundations of all our preſent knowledge of the natural hiſtory of inſects.

Some ſpecies of caterpillars form a kind of hammock, in which they eat and go through their varied changes; while others erect a tent, under which they live, until they have conſumed the ſurrounding herbs. They then leave their abodes, and pitch their tents in a more fruitful ſpot.

Many aſſociate together all their lives, others only for a certain period. Thoſe who live together proceed from the ſame moth who depoſited the eggs near each other, or rather laid them in a heap, forming as it were a kind of neſt. Theſe are generally hatched in the ſame day, and live together, conſtituting a new ſpecies of republic, in which all are brethren. They often amount to near ſix hundred in a family, though they are frequently to be found with only about two hundred. Of theſe ſocial caterpillars there are ſome ſpecies which never quit the ſociety while they are in a larva ſtate, even placing the chryſalis cloſe together. There are other kinds who aſſociate only for a ſhort period.

Among the vaſt variety of inſects which inhabit the oak, there is a ſpecies of caterpillar which live ſeparate till they arrive at a certain age: they then aſſemble together, and do not quit each other till they attain their perfect ſtate. As the number which are thus aſſembled is conſiderable, the neſt is alſo very large. They remain in-doors during the day, not leaving their habitation till ſun-ſet. When they go out, one of the body precedes the reſt as a chief, whom they regularly follow: when the leader ſtops, the reſt do the ſame, and wait till it goes on again, before they recommence their march. The firſt file generally conſiſts of a ſingle caterpillar, which are ſucceeded by a double file, theſe by three in a row, which are then followed by files of five, and ſo on. They keep exceeding cloſe to each other, not leaving any interval either between the ranks, or thoſe in each rank: all of them following their captain in every direction, whether ſtrait or crooked. After they have taken their repaſt, which is done on the march, they return to their neſt in the ſame order in which they ſet out.

This mode is followed till they are full grown, when each forms a cone, in which it is changed into a chryſalis. Mr. Bonnet has ſhewn, that though theſe caterpillars proceed often very far from their neſt, it is by no means difficult for them to get back again, becauſe they ſpin over all the places in their rout. The firſt leads the way, the ſecond follows ſpinning, the third ſpins after the firſt and ſecond, and ſo on with the reſt. All theſe threads form by degrees a ſmall ſhining track, a little path; and all theſe paths meet at the neſt. To be fully convinced of the uſe of theſe threads, let any one but break the continuation of them in ſome place or other, and he ſhall ſee the little caterpillars turn back, as if they were at a loſs, till one more daring than the reſt reſtores the communication by ſpinning new threads.

The reader who is deſirous of a fuller information concerning the habits of theſe, as well as many other inſects, muſt be referred to the laborious and intereſting memoirs of M. de Reaumur. Happy if he ſhould, like M. de Geer, be induced thereby to follow the ſteps of ſo great a maſter; he will derive from thence a continual ſource of new pleaſures and increaſing delights; and the more he extends the boundaries of his obſervations, the more he will be convinced that INFINITY is, as it were, impreſſed on all the works of the Creator.

Different ſpecies of caterpillars are often to be found in great numbers on the ſame tree or plant; but then as they ſeem to have no connection with each other, and the actions of the one have no influence on the other, they may be conſidered as ſolitary; but there are others who ſeem ſtill more independent of each other, and greater friends to ſolitude, conſtructing a lodging, formed of leaves tied together with conſiderable ingenuity, in which they live as in a hermitage. The operation by which theſe tie the leaves together, is far ſurpaſſed by another kind, who fold and bend one part of the leaf till it meets the other. Theſe are again exceeded by thoſe who roll the leaves which they inhabit. For this purpoſe, the caterpillar chuſes a part of a leaf which it finds in ſome degree bent: here it eſtabliſhes it's abode, and begins it's work, moving the head with great velocity, in a curved line, or rather vibrating it like a pendulum, the middle of the body being the center on which it moves. At each motion of the head a thread is ſpun, and fixed to that part to which the head ſeems to be applied. The threads are extended from the bent to the flat part of the leaf, being always adjuſted, both in length and ſtrength, to the nature of the leaf, and the curvature which is to be given to it.

M. de Geer attending to the operations of a ſpecies of this kind of caterpillar, obſerved, that at each new thread it ſpun, the edges of the leaf inſenſibly approached to each other, and were bent more and more, in proportion as the caterpillar ſpun new threads: when the laſt thread that was ſpun was tight, that which preceded it was looſe and floating in the air. To effect this, the caterpillar, after it has fixed a thread to the two edges of the leaf, (and before it ſpins another) draws it towards itſelf by the hooks of it's feet, and by this means bends the leaf; it then ſpins another thread, to maintain the leaf in this poſition, which it again pulls towards itſelf, and repeats the operation, till it has bent the leaf in it's whole direction. It now begins again, placing the threads further back upon the bent part of the leaf, and by proceeding in this manner, it is rolled up; when it has finiſhed this buſineſs, it ſtrengthens the work, by faſtening the ends of the leaf together. The habitation thus formed is a kind of hollow cylinder, open to the light at both ends, the ſides of it affording the inſect food and protection, for within it the creature feeds in ſafety. In the ſame caſe they are alſo transformed: at the approach of the change the caterpillar lines the rolled leaf with ſilk, that the rough parts of it may not injure the chryſalis.

A great number of the ſmaller larva require an artificial covering, to protect them from the open air. Among theſe, ſome inhabit the interior parts of leaves, making their way between the ſuperior and inferior membranes, living upon the parenchymous parts of the leaf: and as they are exceeding ſmall, a leaf affords them a ſpacious habitation. If the diſtance between the membranes is not large enough for them, they enlarge the ſpace by forming different folds in one of them, in which they can move with eaſe: from theſe circumſtances they have been named by Mr. Reaumur miners of leaves. This illuſtrious author has deſcribed theſe larva, the flies into which they are changed, and all the various methods made uſe of by them in performing this work. Some mine a large oval or circular ſpace; others form a kind of gallery, which are ſometimes ſtrait, ſometimes crooked. They only leave a thin membrane on the upper ſide of the leaf; but they leave the under ſide more ſubſtantial. One ſpecies of moth which proceeds from theſe larva is very ſmall, but exceedingly beautiful.

The larva of the phryganea moſtly live in little caſes of their own building, which are formed of a variety of materials, that they train after them in the water wherever they go. Theſe caſes are generally cylindrical, and open at both ends; the inſide is lined with ſilk ſpun by the larva, the outſide formed of different ſubſtances, as bits of reed, ſtone, gravel, and ſome entirely of ſmall ſhells, &c. which they arrange and manage with ſingular dexterity. They never quit this caſe. When they walk they put out the head, and a few of the firſt rings of the body, training the caſe after them.

Having lived in the water for ſome time, they become inhabitants of the air. They aſſume the pupa form in the water, cloſing up the two ends of the caſe with bars of ſilk, by which it is ſecured from the attacks of it's enemies; and at the ſame time there is a free paſſage for the water, which is ſtill neceſſary for it's exiſtence; at a proper period the pupa forces it's way through the caſe, and makes for the land, where it's further change inſtantly commences, and is ſoon completed.

We ſhall cloſe theſe ſpecimens of the induſtry of inſects with an account of that which is diſplayed by the larva of the tinea. The greateſt part of the body of theſe little creatures, except the head and ſix fore feet, is covered over with a thin tender ſkin; the body of the inſect is cylindrical, and lodged in a tube which is open at both ends. Soon after they are born they begin to cover themſelves, and are, therefore, ſeldom to be found but in theſe tubes or caſes. They are, in general, ſo ſmall, that it is not eaſy to diſtinguiſh the caſes without a magnifier; but as the body lengthens, the caſe becomes too ſhort; it is, therefore, part of it's daily employ to lengthen the caſe. For this purpoſe, it extends the head beyond the tube, and having found the materials which anſwer it's purpoſe, it tears it off, and brings it to the end of the tube, and fixes it there, repeating this manœuvre till it has ſufficiently lengthened it; after it has finiſhed one end, it turns itſelf round within the caſe, and performs the ſame operation at the other.

This does not terminate their labours, for the tube muſt alſo be increaſed in diameter, as it ſoon becomes too ſmall for the body; the means they make uſe of to enlarge it, is preciſely the ſame as we ourſelves ſhould adopt under ſimilar circumſtances. The inſect ſlits the tube at the two oppoſite ſides, at the ſame end, and inſerts in the ſlit two pieces of the required ſize; it then performs the ſame at the other end. By this means they ſoon enlarge it ſufficiently, without expoſing themſelves to the air during the operation. The outſide of theſe caſes is made of ſilk, hair, &c. The inſide is of ſilk only. Their covering always partakes of the colour of the cloth, or tree, &c. from whence it was taken. If it paſſes over a red piece, the colour will be red. When they are come to their perfect growth, they abandon the cloth, and ſeek for a proper place wherein they may paſs from their preſent to a more perfect ſtate.

I cannot conclude this long chapter better than in the words of Mr. Stillingfleet. "Many are apt to treat with contempt any man whom they ſee employed in poring over a moſs, or examining

ing an inſect, from day to day, thinking that he ſpends his time and his life in unimportant and barren ſpeculations; yet were the whole ſcene of nature laid open to our views, were we admitted to behold the connections and dependencies of every thing on every other, and to trace the œconomy of nature through the ſmaller as well as greater parts of this globe, we might, perhaps, be obliged to own we were miſtaken; that the ſupreme architect had contrived his works in ſuch a manner, that we cannot properly be ſaid to be unconcerned in any one of them; and therefore, that ſtudies, which ſeem upon a ſlight view to be quite uſeleſs, may in the end appear to be of no ſmall importance to mankind. Nay, were we only to look back into the hiſtory of arts and ſciences, we muſt be convinced that we are apt to judge over haſtily of things of this nature. We ſhould there find many proofs that he who gave this inſtinctive curioſity to ſome of his creatures, gave it for good and great purpoſes, and that he rewards with uſeful diſcoveries all theſe minute reſearches.

"It is true this does not always happen to the ſearcher, or his contemporaries, nor even ſometimes to the immediate ſucceeding generation; but I am apt to think, that advantages of one kind or other always accrue to mankind from ſuch purſuits; ſome men are born to obſerve and record what perhaps by itſelf is perfectly uſeleſs, but yet of great importance to another who follows and goes a ſtep farther, ſtill as uſeleſs; to him another ſucceeds, and thus by degrees, till at laſt one of a ſuperior genius comes, who laying all that has been done before this time together, brings on a new face of things, improves, adorns, exalts human ſociety.

"All thoſe ſpeculations concerning lines and numbers, ſo ardently purſued, and ſo exquiſitely conducted by the Grecians, what did they aim at? or what did they produce for ages? a little arithmetic, and the firſt elements of geometry, were all they had need of. This Plato aſſerts; and though, as being himſelf an able mathematician, and remarkably fond of theſe ſciences, he recommends the ſtudy of them; yet he makes uſe of motives that have no relation to the common purpoſes of life.

"When Kepler, from a blind and ſtrong impulſe, merely to find analogies in nature, diſcovered that famous one between the diſtance of the ſeveral planets from the ſun, and the periods in which they complete their revolutions, of what importance was it to him or the world?

"Again; when Galileo, puſhed on by the ſame irreſiſtible curioſity, found out the law by which bodies fall to the earth, did he, or could he, foreſee that any good would come from his ingenious theorems? or was any immediate uſe made of them?

"Yet had not the Greeks puſhed their abſtract ſpeculations ſo far, had not Kepler and Galileo made the above-mentioned diſcoveries, we never could have ſeen the greateſt work that ever came from the hands of man, Sir Iſaac Newton's Principia.

"Some obſcure perſon, whoſe name is not ſo much as known, diverting himſelf idly, as a ſtander-by would have thought, with trying experiments on a ſeemingly contemptible piece of ſtone, found out a guide for mariners on the ocean, and ſuch a guide as no ſcience, however ſubtil and ſublime it's ſpeculations may be, however wonderful it's concluſions, would ever have arrived at. It was mere curioſity that put Sir Thomas Millington upon examining the minute parts of flowers; but his diſcoveries have produced the moſt perfect and moſt uſeful ſyſtem of botany that the world has yet ſeen.

"Other inſtances might be produced to prove, that bare curioſity in one age is the ſource of the greateſt utility in another; and what has frequently been ſaid of chymiſts, may be applied to every other kind of vertuoſi. They hunt, perhaps, after chimeras and impoſſibilities; they find ſomething really valuable by the bye. We are but inſtruments under the Supreme Director, and do not ſo much as know, in many caſes, what is of moſt importance for us to ſearch after; but we may be ſure of one thing, viz. that if we ſtudy and follow nature, whatever paths we are led into, we ſhall at laſt arrive at ſomething valuable to ourſelves and others, but of what kind we muſt be content to remain ignorant."

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# C H A P. VI.

## GIVING SOME ACCOUNT OF THE ANATOMICAL STRUCTURE OF THE COSSUS, OR CATERPILLAR, WHICH IS FOUND IN THE TRUNK OF THE WILLOW; AND SEVERAL OTHER MISCELLANEOUS OBJECTS.

OF all the modifications of which matter is ſuſceptible, the moſt noble is undoubtedly the organization thereof. In the ſtructure of animals, the Sovereign Wiſdom is exhibited to us in the moſt ſtriking manner. The body of an animal is a little particular ſyſtem, more or leſs complicated, and which, like the ſyſtem of the univerſe at large, is the reſult of the combination and connection of a multitude of different pieces, which all conſpire to produce one general effect, the manifeſtation of the principle which we term life. So wonderful are theſe combinations, that we are incapable of comprehending, or even of admiring ſufficiently, the aſtoniſhing apparatus of ſprings, levers, counterweights, of tubes of different diameters, &c. which conſtitute theſe organical machines. The interior parts of the inſect, the moſt vile in appearance, would abſorb all the powers of the moſt able anatomiſt. He would be loſt in the labyrinth as ſoon as he attempted to explore all it's windings. A truth that will be evident to every one who conſiders only the ſmall portion of the anatomy of the caterpillar here exhibited, which is extracted from the wonderful work of Mr. Lyonet, entitled "Traité Anatomique de la Chenille qui ronge le Bois de Saule," to which the reader muſt be referred for a more ample account of the ſtructure of this animal; enough will be given here to convince every one of the power and uſe of microſcopic glaſſes in the diſplay of the wonders of creation; enough will be introduced to prove to the reader that it is not matters of magnitude which only engage the attention or art of the Almighty, "he delights to be elaborate on the minuteneſſes and minims of nature; to open his immenſity, as it were, within a ſpeck; to laviſh his ſkill and ornaments on inſects and butterflies; and to inform ants and bees with better ſagacity and ſcience than the moſt laboured ſyſtems of human policy can exhibit. For the littleneſſes of our God are great beyond conception, and while the univerſe cannot contain him, his wiſdom and might, his goodneſs and glory, and the fulneſs of his infinity, are entire, and diſplayed through every point of infinite ſpace."*

Our theme no great (of ONE excluſive) knows;
No little when from ONE, that ONE it flows.
* * * * * * * *
Where ONE, and only ONE, is truly GREAT!
All equidiſtant, or alike all near,
The reptile minim, or the rolling ſphere;
Alike minutelv great, or greatly leſs,
In form finite, INFINITUDE expreſs;
Expreſs the ſeal of CHARACTER DIVINE,
And bright, thro' HIS INFORMING RADIANCE SHINE.

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* Brooke's Juliet Grenville, vol. 1, p. 198.

We ſhall firſt give a general deſcription of the animal itſelf, and then proceed to explain thoſe anatomical parts of it which are repreſented at Fig. 1, 2, 3, 4, 5, 6, 7, of Plate XII. This inſect, like every other caterpillar, proceeds from an egg, which the parent moth takes care to depoſit in general againſt the trunk of the willow; to this it is attached by a viſcous humor, which ſoon becomes ſo hard that the rain cannot diſſolve it.

The egg is very ſmall, of an oblong ſpheroidal ſhape; when examined by the microſcope, we find broad waving furrows running through the whole length of it, which are again croſſed by cloſe ſtreaks, giving it the appearance of a wicker baſket. It is probable that they are hatched ſome time in Auguſt, becauſe the ſmall caterpillars are often to be found in September. When ſmall, they are generally to be met with under the bark of the tree to which the eggs were fixed; a humid oozing from the hole they have made to get under the bark, is often a direction where to ſearch for them; though it is not always a certain ſign, becauſe the ſame effect is often occaſioned by other inſects.

Theſe caterpillars change very little in their colour, being nearly the ſame when they are full grown as when they are very young. Like many others they are capable of ſpinning as ſoon as they are born. They change alſo ſeveral times their ſkin, but as it is almoſt impoſſible to raiſe them under a glaſs, it is not eaſy to determine how many times they moult or put off their ſkin; if we are to judge of the number of times by the difference in ſize between the new born and full grown caterpillar; and if we compare theſe with the increaſe of the head, every time it moults; we may reaſonably conclude, that it changes oftener than the generality of caterpillars, that is, more than four, five, or ſix times, for ſome have been obſerved to moult above nine times.

We have already taken notice of theſe changes in the laſt chapter. The caterpillar generally faſts for ſome days previous to the moulting, the fleſhy and other interior parts of the head are then detached from the old ſkull, and retire as it were within the neck; it is ſoon however cloathed with pieces ſimilar to thoſe it has abandoned, only larger and at firſt very ſoft. When the new ſkin and the other parts are formed, the old ſkin is to be opened, and all the members withdrawn from it, an operation naturally difficult, but which muſt be rendered more ſo from the ſoft and weak ſtate of the little creature at that time. The caterpillar is always much larger after the change.

It appears from the experiments of M. Lyonet, that this caterpillar generally paſſes two winters at leaſt, if not three, before it aſſumes the pupa ſtate, but then it neither acts nor eats in the winter, forming at the approach of this ſeaſon a little caſe or habitation, the inſide of which is lined with ſilk, and the outſide covered with ſmall pieces of wood like fine ſaw-duſt: incloſed in this it waits the return of ſpring. They are ſometimes three inches and an half long when full grown, the ſmalleſt about two inches. The ſize which they attain is very great, if compared with that of the new born caterpillar, which does not exceed one twelfth of an inch, an increaſe in growth much ſuperior to that of the larger animals.

It generally prepares for the pupa ſtate in the month of May; it's firſt care being to find a hole in the tree ſufficient to give iſſue to the moth: and if it finds none proper for the purpoſe, it makes one equal in ſize to the future pupa. The hole being made or found, it begins to conſtruct a caſe or cone, which it forms of thin pieces of wood, uniting them together, by ſilk, into an ellipſoid ſhape; the outſide is formed of little ſticks united together in all directions; the caterpillar takes care that the pointed end of the caſe may be always oppoſite to the mouth of the hole: having finiſhed the outſide of the caſe, it lines the inſide with a ſilken tapeſtry, of a cloſe texture in all parts, except the pointed end, and where the tiſſue is looſer, in order to facilitate it's eſcape at a proper ſeaſon. The work being finiſhed, the caterpillar places itſelf in the caſe in ſuch a manner, that it's head may always lay towards the opening of the hole in the tree or pointed end of it's caſe.

In this ſtate it remains at reſt for ſome time; the colour of the ſkin firſt becomes pale, afterwards the whole ſkin appears brown. The interior parts of the head are detached from the ſkull, the legs retire or withdraw themſelves from their exterior caſe, the body ſhortens, the poſterior part grows ſmall, while the anterior part ſwells ſo much, as at laſt to burſt the ſkin, which, by a variety of motions, it puſhes down to the tail, and thus exhibits the pupa, in which the parts of the future moth may be eaſily traced.

The covering of the pupa is at firſt ſoft, humid, and white, but it ſoon dries and hardens, and is then of a marron colour; the fore-part, in which the lineaments of the head, the legs, and the wings of the moth may be diſcovered, is quite immoveable, but the poſterior part is moveable. The anterior end of this pupa is furniſhed with two horns, one above the other, under the eyes; there are alſo on it's back ſeveral rows of points one under the other, the points directed towards the tail. The pupa remains in it's caſe for ſome weeks; as ſoon as the moth that is formed therein finds itſelf enabled to break the bonds by which it is confined, it begins to agitate itſelf within the caſe; the points are then rendered of eſſential ſervice, thoſe on the back ſerve as a fulcrum, to prevent it's ſlipping backwards, while it is opening the hole of the cone with thoſe on the head.

The new-formed moth labours in general about a quarter of an hour before it can effectually open the caſe. This being done, by redoubled efforts it enlarges the hole, and preſſes itſelf forwards, till it arrives at the edge, where it makes a ſudden ſtop; for if it advanced further it would fall to the ground, and probably loſe it's life, or be materially injured by the fall. Here then the pupa repoſes itſelf for a time, after which the moth begins to diſengage itſelf from the bonds which confine it; when it has eſcaped from the pupa, it fixes itſelf againſt the trunk of the tree, with the head upwards, and often remains in this ſituation for ſome hours, during which time the wings and members are perfectly developed, and rendered fit for action. I have been informed by Mr. Marſham, that it generally puſhes at leaſt one-third of the caſe out of the hole before it halts.

## DESCRIPTION OF PLATE XII.

The body of the caterpillar in this plate is divided into twelve parts, correſponding to it's rings. Theſe diviſions are marked in Fig. 2 and 3, Plate XII. by the numbers 1, 2, 3, up to 12; to the firſt number the word RING is annexed.

Each of theſe rings is diſtinguiſhed from that which follows, and that which precedes it, by a kind of neck or ſmall hollow part. By conceiving a line to paſs through theſe necks, and forming boundaries to the rings, we acquire twelve more diviſions; theſe are alſo marked 1, 2, 3, 4, &c. to 12, but to the firſt the word DIVISION is affixed.

To facilitate further the deſcription of this animal, M. Lyonet found it neceſſary to form ſome ideal diviſions, or rather lines, to paſs through it. He therefore ſuppoſed, firſt, a line to paſs down the middle of the back, and this he called the ſuperior line, becauſe it marked the moſt elevated part of the back of the caterpillar; the inferior line, one directly oppoſite to the former, and paſſing from the head down the belly to the tail.

In all caterpillars, on the right and left of each ring, except the ſecond, third, and laſt, there is a little organ, ſomething to appearance like an elliptic ſpot; theſe are termed the ſpiracula, and have been mentioned ſeveral times in this work; as they are ſituated nearly at equal diſtances from the ſuperior and inferior lines, they furniſh us with a further ſub-diviſion, called the lateral lines, which paſs through the ſpiracula, the one on the right, the other on the left ſide of the caterpillar.

Theſe four lines, which we may conceive to divide the caterpillar longitudinally into four equal parts, are attended with this remarkable circumſtance, that each of them mark the place under the ſkin that is occupied by a conſiderable viſcera; the heart, or rather the thread of hearts, lies under the ſuperior line; the ſpinal marrow immediately over the inferior line; the two tracheal arteries follow the courſe of the lateral lines.

At equal diſtances from the ſuperior and two lateral lines, and the inferior lines, we may ſuppoſe four intermediate lines. The two between the ſuperior and lateral lines are called intermediate ſuperior lines; the two others which are oppoſite to them, and between the lateral and inferior lines, the intermediate inferior lines.

## AN EXPLANATION OF FIGURES 1 AND 2, PLATE XII; OR AN ACCOUNT OF THE MUSCLES OF THE CATERPILLAR WHEN OPENED BY THE BELLY.

Of all the interior parts of the caterpillar, none preſent ſo beautiful a view, or a more wonderful and ſymmetrical arrangement, than that of the muſcles; the more ſo, if they are taken away by equal ſtrata on both ſides, ſo as to expoſe at the ſame time the ſimilar muſcles on the oppoſite ſide, and by this means exhibit to the aſtoniſhed eye their exact form and correſpondence.

Fig. 1 and 2 is a repreſentation of the muſcles of two different caterpillars, opened at the belly, and ſuppoſed to be joined together at the ſuperior lines; for as the muſcles on the oppoſite ſide of each caterpillar are perfectly ſimilar, it was not only unneceſſary to repreſent them, but by joining another view of the muſcles, as in Fig. 2, we are enabled to exhibit thoſe muſcles which were covered in Fig. 1, and by this means ſave much time in the deſcription, and the addition of another plate.

The dorſal muſcles, or thoſe of the back, are marked by capital letters; the gaſtric muſcles, or thoſe of the belly, by Roman letters; the lateral muſcles by Greek characters. Mr. Lyonet has only given a name to thoſe among the latter, which are marked θ; theſe are placed upon all the diviſions, from the ſecond to the eleventh; they are called dividing muſcles, on account of their ſituation; a muſcle that has been once marked with a letter always retains the ſame, both in the deſcription and the other figures.

## PREPARATION.

The caterpillar was emptied, and the muſcles freed from the maſſes of fat, the nerves, and other veſſels, which, if they had been left, would have confuſed the view of the muſcles, and rendered it difficult to diſtinguiſh and trace them.

## FIRST RING.

The muſcle A is double. The anterior one is thick at top, and ſeems to be divided into different muſcles on the upper ſide, but it has no ſuch appearance on the under ſide. One of their inſertions is towards the head, at the ſkin of the neck; the other inſertion of the firſt muſcle A is a little above, and that of the ſecond muſcle A is a little below the firſt ſpiraculum, near which they are fixed to the ſkin.

α is long and ſlender; it is fixed by it's anterior extremity under the gaſtric muſcles (a and b) of the firſt ring, to the circumflex ſcale of the baſe of the lower lip. After having paſſed under ſome of the arteries, it introduces itſelf under the muſcle θ, and communicates there with the muſcle c of the ſecond ring.

β is ſometimes ſingle, ſometimes double, and ſometimes triple; it is hardly poſſible to open the caterpillar by the belly without breaking it; the anterior fixture is to the poſterior edge of the ſide of the parietal ſcale; the lower fixture is at the middle of the ring, near the inferior line.

The muſcles marked ζ are three in number; the firſt is fixed at one extremity near the lower edge of the upper part of the parietal ſcale; the other end divides itſelf into three or four tails, which are fixed to the ſkin of the caterpillar under the muſcle δ.

The anterior end of the ſecond has it's inſertion near the former; that of the third a little under the two foregoing, at the ſkin of the neck, under the muſcle A. Theſe two laſt paſſing over the cavity of the firſt pair of limbs, are fixed by ſeveral tails to the edge oppoſite to this cavity.

In this ſubject there are two muſcles marked δ, ſometimes there is only one; their anterior fixture is to the lower edge of the parietal ſcale; the other ends are inſerted in the firſt fold of the ſkin of the neck, on the belly ſide.

$\beta$ and $\delta$ are beſt ſeen in Fig. 3, where they are entire, not being injured by an unnatural extenſion.

### OF THE SECOND AND FOLLOWING RINGS, TO THE LAST.

Two large dorſal muſcles, A and B, are diſcovered in the ſecond and four following rings. There are three, A, B, C, in the 7th, 8th, 9th, and 10th rings; four, A, B, C, D, are to be ſeen at the 11th ring; and five, A, B, C, D, E, at the anterior part of the 12th ring.

All theſe files, or ranges of muſcles, A, B, C, and E, as well as the gaſtric muſcles, a, b, c, d, appear at firſt ſight only as a ſingle muſcle, running nearly the whole length of the caterpillar; but when this is detached from the animal, it is found to conſiſt of ſo many diſtinct muſcles, each muſcle only the length of one of the rings; their extremities are fixed to the diviſions of each ring, excepting the muſcle a, which at the 6th, 7th, 8th, and 9th rings has it's inſertions rather beyond the diviſions. Each row of muſcles appears as one, becauſe they are cloſely connected at top by ſome of the fibres, which paſs from one ring to the other. The muſcles A, B, C, E, from their ſituation may be called the right muſcles of the back; and for the ſame reaſon the muſcles a, b, c, and d, may be called the right muſcles of the belly.

From the third ring the muſcles A, which are twelve in number, gradually diminiſh in breadth to the lower part of the laſt ring; at the 8th and three following diviſions they communicate with the muſcles B, and at the 11th with D. In the lower part of the laſt ring, A is much broader than it was in the preceding ring; one extremity of it is contracted, and communicates with B; the lower inſertion is at the membrane I, which is the exterior ſkin of the fœcal bag.

It may be proper to obſerve, that the muſcles, A and B, of the lower part of the laſt ring, cannot be ſeen until a large muſcle is removed, which on one ſide is fixed to the ſubdiviſion of this ring, on the other to the fœcal bag.

The right muſcles B are alſo twelve in number; they begin at the ſecond ring, and grow larger from thence to the 7th: from the 7th to the ſubdiviſion of the 12th they are one-half narrower; the deficiency in width is ſupplied by the ſix muſcles C, which go with it from the 7th to the ſubdiviſions of the 12th ring. The muſcles B and C have a lateral communication at the 8th, 11th, and 12th diviſions; C is wanting at the ſubdiviſion of the 12th ring; it's place is filled up by B, which becomes broader in that part.

We have now only to ſpeak of the three floating muſcles V. The firſt of theſe originates at the firſt ring, from whence it introduces itſelf under N, where it is fixed, and then ſubdivides, and paſſes under parts which render it inviſible in this figure.

The ſecond floating muſcle begins at the ſecond diviſion, being fixed to the anterior extremity B of the ſecond ring; from thence it directs itſelf towards the ſtomach, and after communicating with the caſe of the corpus craſſum, it divides and ſpreads itſelf into eight muſcles, which run along the belly.

The third, V, begins at the third diviſion, originating partly at the ſkin, partly at the junction of the muſcles B of the ſecond and third ring. It directs itſelf obliquely towards the belly, meeting it near the third ſpiraculum; branching from thence, it forms the oblique muſcles of this viſcera.

The thin long muſcle θ, which is at the ſubdiviſion of the laſt ring, and covers the anterior inſertion of the large muſcle (a), where the ring terminates, (il eſt ſans paire) it is ſingle; it begins at one extremity of the muſcle c, at the fore part of the ring, runs along the ſubdiviſion, round the belly of the caterpillar, and finiſhes on the other ſide, at the extremity of a ſimilar muſcle C.

## EXPLANATION OF FIG. 2, PLATE XII.

### PREPARATION.

All the dorſal muſcles, thirty-five in number, were taken out, as well as the ſeven lateral ones which have been deſcribed in the preceding figure.

All the ſtrait muſcles of the belly were alſo taken away, as well as the muſcular roots ç, and the ends of the gaſtric muſcles c, which are at the third and fourth diviſion.

At the ſecond diviſion the middle of the muſcle θ was removed, the extremities only being left to point out where it was inſerted.

The tracheal artery was alſo removed.

## EXPLANATION OF THE FIRST RING.

We ſee fully here the muſcles C ∗ ζ and (i) which were but partly ſeen in the preceding figure, and the gaſtric muſcles g, which were not ſeen there.

The muſcles C ∗ occupy two rings; it is very difficult to determine their preciſe number; ten may be counted at the anterior end, which are collected in one faſcicle, and inſerted at the ſide of the upper part of the parietal ſcale, immediately under the muſcles ζ; towards the lower end theſe muſcles ſpread like a fan, and a greater number may be counted; they communicate laterally with each other by reciprocal branches, which makes it difficult to determine whether they ſhould be conſidered as ſingle muſcles, or as ſo many diſtinct ones. The lower extremity of all but the two laſt croſs, at the ſuperior line of the ſecond ring, the tails of ſimilar muſcles on the oppoſite ſide; after which, they are inſerted at the ſkin beyond this line.

There are five lateral muſcles ζ, ſometimes ſix; they have their firſt fixture at the ſide of the head, their lower part widens, and is inſerted lengthways in the ſecond diviſion.

The muſcles θ of the firſt ring, as well as the ſimilar muſcles of the nine other rings, are better ſeen in this than in Fig. 1; as they are placed over the diviſions, they may be termed dividing muſcles. That of the ſecond diviſion has been ſeparated to ſhew the muſcles underneath. It is ſingle as well as that of the third diviſion; that of the fourth is double; they appear more numerous in the ſucceeding diviſions, though they are, in general, only double, ſeldom triple, but much thicker; thoſe of the third and fourth diviſion paſs over the tracheal artery, whilſt all the others go under it: we find them at all the diviſions but the firſt and laſt.

## SECOND RING.

The dorſal muſcles are ſufficiently ſeen in this ring, to enable the obſerver to form ſome idea concerning them.

C is the only one which is fairly expoſed; it has it's poſterior inſertion at the third diviſion, near the intermediate ſuperior line, from whence advancing obliquely it becomes forked, one branch paſſes under the dividing muſcle, and is fixed to the ſkin, from whence it again proceeds, and forms the fine long muſcle $\alpha$ of the firſt ring. The other branch is fixed to the ſkin, near the lateral line, under the muſcle $\gamma$ of the ſecond ring.

When the muſcle C and ſome of the muſcles C $*$ are removed, we ſee the whole of D; the direction of this muſcle is entirely contrary to that of C.

After taking away D, we diſcover the muſcle E, which is inclined towards the ſame ſide as C, but not ſo obliquely. By taking away E we are enabled to ſee the muſcle F, which is parallel to D: theſe three laſt muſcles are fixed to the diviſions which terminate the rings; the lateral muſcles are not ſeen ſo as to be deſcribed.

### THE THIRD RING

Preſents four dorſal muſcles, C, D, E, F. The firſt dorſal muſcle, C, is inſerted at the third diviſion under the muſcles $\theta$ and $\alpha$, where it communicates, by means of ſome fibres, with the muſcle f of the ſecond ring; from thence it proceeds obliquely towards the intermediate ſuperior line, and is fixed at the fourth diviſion.

As ſoon as C is retrenched, the muſcle D is ſeen; this grows wider from the anterior extremity; it lies in a contrary direction to the muſcle C, and is inſerted into the third and fourth diviſions.

The muſcle E lies in the ſame direction as the muſcle C, but not ſo obliquely; the lower inſertion is at the fourth diviſion, the other is at the third, immediately under C.

The muſcle F is nearly parallel to D, which joins to it; the firſt inſertion is viſible, the other is at the fourth diviſion, under the muſcles E and G.

There are no lateral muſcles to be deſcribed in this ring.

### THE EIGHT FOLLOWING RINGS.

There are only two dorſal muſcles, and no lateral ones, to be deſcribed in theſe rings.

Of theſe two muſcles, D is the only one that is altogether ſeen; it is very large, and diminiſhes gradually in breadth, from ring to ring, to the laſt, branching off in ſome places.

E is one of the ſtrait muſcles of the back, and is inſerted at the diviſions of it's own ring, under the dividing muſcles $\theta$.

### ANTERIOR PART OF THE TWELFTH RING.

There are three dorſal muſcles, D, E, F, to be conſidered in this part.

The muſcle D is ſimilar to D of the preceding ring, only that it terminates at the ſubdiviſion of it's ring, and is conſequently only half as long.

E is of the ſame length, and differs from the muſcle E of the preceding ring only in it's direction.

The muſcle F is parallel to E, and ſhorter; it's anterior end does not reach the twelfth diviſion.

### POSTERIOR PART.

There is only one dorſal muſcle here, which is faſtened by ſome ſhort muſcles to the ſubdiviſions of the laſt ring, traverſing the muſcles $\alpha$, and being fixed there, as if deſigned to ſtrengthen them, and to vary their direction.

$\alpha$ is a ſingle muſcle; it's anterior inſertion is viſible, the other end is fixed to the bottom of the foot of the laſt leg; it is uſed to move the foot.

The anterior part of the muſcle $\beta$ is divided into three or four heads, which croſs the ſuperior line obliquely, and are fixed to the ſkin a little above it. The other end is faſtened to the membrane T.

## AN EXPLANATION OF FIGURES 3 AND 4, OF PLATE XII. OR AN ACCOUNT OF THE MUSCLES OF THIS CATERPILLAR WHEN IT IS OPENED AT THE BACK.

### PREPARATION FOR FIG. 3.

The muſcles were not only diſengaged from all extraneous matter, as before, but as it repreſents the third figure of Mr. Lyonet, on the muſcles of the caterpillar's back a great many had been removed before the parts of the inſect appeared, as delineated in this figure.

### FIRST RING.

Only two gaſtric muſcles, c d, are ſeen here; c is broad, and has three or four little tails; the firſt fixture is at the baſe of the lower lip, from whence it deſcends obliquely, and is fixed between the inferior and lateral line.

The little muſcle d is faſtened on one ſide to the firſt ſpiraculum, and on the other ſide, a little lower to the intermediate inferior and the lateral line; it ſeems to be the antagoniſt of P, which opens the ſpiracula.

The lateral muſcles $\beta$ $\delta$ are very well ſeen in this figure; the poſterior fixture of $\delta$ is under the muſcle C, near the ſkin of the neck; $\beta$ is fixed a little on the other ſide of C, at the middle of the ring.

### SECOND RING.

Three gaſtric muſcles, g, h, i, appear here; g and h are fixed at the folds which terminate the ring; i has only it's anterior fixture there.

h is triple; in one of the diviſions it is ſeparated into two parts.

i approaches more the inferior line, and is fixed a little beyond the middle of the ring, where the ſimilar muſcle on the oppoſite ſide is forked to receive it.

### THIRD RING.

h, which was triple in the preceding ring, is double here; that part which is neareſt the inferior line is the broadeſt; it has three tails, of which only two are viſible.

The muſcle i is exactly ſimilar to that of the preceding ring, and is croſſed in the ſame manner by the muſcle from the oppoſite ſide of the ring.

## THE EIGHT FOLLOWING RINGS.

The muſcle f, in all theſe rings, is very broad and ſtrong; the anterior fixture is at the intermediate inferior line, on the fold of the firſt diviſion of the ring; the other fixture is beyond the lower diviſion, with this difference, that at the 10th and 11th rings the fixture is at the laſt fold of it's ring; whereas in the others it paſſes over, and is inſerted in the ſkin of the following ring.

In all theſe rings the firſt extremity of g is faſtened to the fold which ſeparates the ring from the preceding one, and is parallel to f, and placed at the ſide of it.

The ſix firſt, g, are forked; that of the fourth ring is very much ſo; it does not unite till it is near it's anterior inſertion. The longeſt tail lays hold of the following, and is inſerted near the inferior line; the other inſerts itſelf near the ſame line, at about the middle of it's own ring.

The two laſt, g, do not branch out, but terminate at the diviſions without reaching the following ring.

The muſcle h is placed at the ſide of f, has nearly the ſame direction, and finiſhes at the folds of the ring.

### ANTERIOR PART OF THE TWELFTH RING.

The only gaſtric muſcle left here is e; it is placed on the intermediate inferior line; in it's direction it ſeparates from it's lateral, and is inſerted at the folds of the upper diviſion, and at the ſubdiviſion of this ring.

### LOWER PART OF THE TWELFTH RING.

c is a large muſcle, with ſeveral diviſions; one placed under (b) of the preceding figure, one extremity is fixed near the lateral line, at the ſubdiviſion of it's ring, the other to the fœcal bag, a little lower than the muſcle b.

### EXPLANATION OF FIG. 4, PLATE XII.

All the gaſtric muſcles deſcribed in the preceding figure diſappear in this, as well as all thoſe lateral and dorſal ones whoſe letters are not found in this figure.

### FIRST RING.

e f g are the gaſtric muſcles, which are beſt ſeen here.

e is narrow and long; it paſſes under and croſſes f, one of it's inſertions is at the lower line, the other is at the lateral, between the ſpiraculum and the neck.

f is ſhort, broad, and nearly ſtrait, placed along the intermediate line, but between it and the lateral; it paſſes under e, and is fixed to the fold of the ſkin which goes from one leg to the other; the lower inſertion is near the ſecond diviſion.

There are ſometimes three muſcles g, and ſometimes four; their lower fixture is about the middle of the ring; the anterior inſertion is at the fold of the ſkin, near the neck.

The muſcles i and h are alſo fixed to the ſame fold; the other end of h is fixed under the muſcle Π, near the ſpiraculum.

Above the upper end of f, a muſcular packet g, formed by the ſeparation of two floating muſcles, may be ſeen; though only imperfectly, as they were injured by the diſſection.

## SECOND RING.

Six gaſtric muſcles, k, l, m, n, o, p, may be pretty well diſtinguiſhed in this ring.

k is a large oblique muſcle, with three or four diviſions, placed at the anterior part of it's ring; the head of it is fixed between the inferior line and it's intermediate one, at the fold of the ſecond diviſion, from whence it croſſes the inferior line, and it's ſimilar muſcle; it terminates to the right and left of this line.

l is a narrow muſcle, whoſe head is fixed to the fold of the ſecond diviſion, the tail of it lies under n, and is faſtened to the edge of the ſkin that forms the cavity for the leg.

m, two muſcles of the ſame obliquity, placed one on the other; the head of it is inſerted in the ſkin, under the muſcle $\beta$, and communicates, by a bed of fibres, with the tail of the muſcle $\gamma$; the other end is fixed to the intermediate inferior line, at the fold of the third diviſion.

n is large and broad; it covers the lower edge of the cavity of the limb, and the extremity of the tail of l; the firſt fixture is at the ſkin, near the intermediate line, from whence it goes in a perpendicular direction towards m, and introduces itſelf under o and m, where it is fixed.

o is narrow and bent, and covers a little the edge of the cavity of the leg; one end terminating there, the other end finiſhes at the third diviſion near m.

p is alſo bent; it runs near the anterior edge of the cavity of the leg; one end meets the head of o, the other end terminates at a raiſed fold, near the inferior line.

On the ſide of the lateral muſcle o there is a triangular muſcle, ſimilar to q of the following ring; it is entirely concealed in this by the muſcle m.

## THIRD RING.

This ring has no muſcle, ſimilar to m of the preceding ring.

k only differs from the muſcle of the ſecond ring, in that it is croſſed by the oppoſite muſcle, whereas k croſſes the oppoſite muſcle.

As the muſcles l, n, o, p, of this ring are ſimilar to thoſe of the preceding one, they need not be deſcribed.

q is a triangular muſcle; the baſe of it is faſtened to the laſt fold of it's ring, on the lower ſide it is fixed to the muſcle o, the ſummit to the ſkin at the edge of the cavity for the leg.

### THE EIGHT FOLLOWING RINGS.

We diſcover here the gaſtric muſcles, i, k, l, m.

The muſcle i is quite ſtrait, and is placed at a little diſtance from the inferior line; it is broad at the fourth ring, but diminiſhes gradually in breadth to the eleventh. It is united at the fourth, but is divided into two heads, which divaricate in the following rings. In the ſix next rings theſe heads are fixed nearly at the ſame place with a and f; in the other two it terminates at the fold of the ring. The anterior inſertion of the firſt and laſt is at the fold, where the ring begins; that of the ſix others is ſomewhat lower, under the place where the muſcle i, which precedes them, finiſhes.

k is an oblique muſcle, whoſe lower inſertion is at the ſkin near i; the other at the intermediate inferior, upon the fold which ſeparates the following ring; it is miſſing in the eleventh ring.

l is a large muſcle which co-operates with M; in opening and ſhutting the ſpiraculum, one of it's fixtures is near the intermediate inferior line, at about the ſame height as i; the tail finiſhes a little lower than the ſpiraculum.

## TWELFTH RING.

There remains here only the gaſtric muſcle d, which is a faſcicle of ſix, ſeven, or eight muſcles; the firſt fixture of theſe is at the ſubdiviſion of the ring, near the inferior line; one or two croſs this, and at the ſame time the ſimilar muſcles of the oppoſite ſide. Their fixture is at the bottom of the foot; their function is to concur with the muſcle $\alpha$, in bringing back the foot, and looſen the claw from what it lays hold of.

We perceive here the muſcle $\alpha$; one of it's inſertions is at the bottom of the foot, near d; the other extremity near the ſubdiviſion of the ring.

## EXPLANATION OF FIG. 5 AND 6, PLATE XII.

The anatomical delineation of the head, which is given at Fig. 5 and 6, ſhould be conſidered as conſiſting of two figures, which join in the middle, being terminated by the inferior and ſuperior lines. It will be impoſſible in this place to give more than a very looſe idea of the head of the caterpillar in theſe two figures, as M. Lyonet found it neceſſary to employ twenty, in order to diſplay properly the organization of this part. Theſe will, however, be ſufficient to give ſome idea of it to thoſe who cannot procure or read the work itſelf; it may alſo ſerve to ſtimulate thoſe who have leiſure to extend further the anatomy of inſects; for it is only by a compariſon of their's with that of man, that we can ever aſcertain their true place in the ſcale of creation. If this compariſon could be accurately diſcovered, the true philoſopher would be able to trace their final cauſe, or rather the originating ſource of their exiſtence, and point out the degree in which they accorded with thoſe laws of goodneſs and truth, by which the univerſe and all it's parts are regulated and governed.

The head, as repreſented in theſe figures, is magnified about three hundred and forty-three times; it is ſeparated from the neck, and diſengaged from the fat. The figures here under conſideration repreſent the head in the third and fourth ſtate of examination, when a great many parts had been removed, in order to diſcover thoſe that are here ſeen.

H H, the two palpi. The truncated muſcles D belong to the lower lip, and form a part of it's moving muſcles. K is the two ganglions of the neck united. I I, the two ſilk veſſels. L, the oeſophagus. M, the two diſſolving veſſels.

ד ג ב א are the continuation of four cephalic arteries. Fig. 5, S S, T T, V V, and Z, are the ten abductor muſcles of the jaw. Fig. 6, under e e and f f, are ſeen four occipital muſcles. a k, a nerve of the firſt pair belonging to the ganglion of the neck; b, a branch of this nerve.

Fig.

### FIG. 7, PLATE XII.

Is an outline of the head, magnified conſiderably more than in the laſt figures, exhibiting the nerves as ſeen from the under part.

Excepting in two or three nerves (and theſe may be eaſily known, becauſe each nerve of the ſame pair is marked with a ſimilar letter), only one nerve of each pair is drawn, as a greater number would have occaſioned much confuſion.

The nerves of the firſt ganglion of the neck are deſigned by capital letters.

The nerves of the ganglion a of the head are diſtinguiſhed by Roman letters.

The nerves of the ſmall ganglion by Greek characters.

Thoſe of the frontal ganglion, except one, by numbers.

## A GENERAL IDEA OF THE INTERIOR PARTS OF THE CATERPILLAR.

Having deſcribed ſo many of the parts as to evince the amazing wonders that are diſplayed in this inſect, I proceed to give a more particular account of the nature of ſome of thoſe parts.

## OF THE DIFFERENT ORDERS OF MUSCLES, BY WHICH THE CATERPILLAR IS ENABLED TO MOVE ALL THE VARIOUS PARTS OF THE BODY.

Theſe muſcles have neither the exterior form, nor the colour of thoſe of larger animals. In their natural ſtate they are ſoft, and have the appearance of a jelly; they are of a greyiſh blue, and the ſilver-coloured appearance of the aerial or pulmonary veſſels, which creep over and penetrate their ſubſtance, exhibits under the microſcope a moſt beautiful ſpectacle. When the caterpillar has been ſoaked for ſome time in ſpirit of wine, they loſe their elaſticity and tranſparency, and become firm, opake, and white; the aerial veſſels diſappear. At firſt ſight they might be taken for tendons, as they are of the ſame colour, and poſſeſs almoſt the ſame luſtre. They are generally flat, and of an equal ſize throughout; the middle ſeldom differs either in colour, ſubſtance, or ſize, from the extremities.

The ends are fixed to the ſkin; the reſt of the muſcle is generally free and floating; ſeveral of them branch out conſiderably; the branches extend ſometimes ſo far, that it is not always eaſy to diſcover whether they are diſtinct and ſeparate muſcles, or parts of another. They are of a moderate ſtrength; thoſe that have been ſoaked in ſpirit of wine, when examined by the microſcope, will be found to be covered with a membrane, which may be ſeparated from them; they then appear to conſiſt of ſeveral parallel bands, directed according to the length of the muſcle. Theſe, when divided by the aſſiſtance of very fine needles, appear to be compoſed of ſtill ſmaller faſcicles of fibres, in the ſame direction, which, when examined with a very deep magnifier, and in a favourable light, appear twiſted like a ſmall cord. The muſcular fibres of the ſpider, which are much larger than thoſe of the caterpillar, are found on examination to conſiſt of two ſubſtances, one ſoft, and the other hard; the laſt is twiſted round the former ſpirally, and thus gives to it the afore-mentioned cord-like appearance.

If the muſcles are ſeparated by means of very fine needles, in a drop of ſome fluid, we find that they are not only compoſed of fibres, membranes, and aerial veſſels, but alſo of nerves; and from the drops of oil that may be ſeen floating on the fluid, that they are alſo furniſhed with many unctuous particles.

The number of muſcles in a caterpillar is very great, exceeding by much thoſe of the human body; the reader may form ſome idea of their quantity, by looking at Fig. 1 and 2, 3 and 4, of Plate XII. They occupy the greateſt part of the head; there is an aſtoniſhing number at the oeſophagus, the inteſtines, &c. the ſkin is as it were lined by different beds of them, placed one under the other, and ranged with very great ſymmetry.

The number of muſcles that our obſerver has been able to diſtinguiſh is truly aſtoniſhing; he found 228 in the head, 1647 in the body, 2066 in the inteſtinal tube, making in all 4041.

THE SPINAL MARROW, and the brain of the caterpillar, if they can be ſaid to have any, ſeems to have very little relation to thoſe of man; in the laſt, the brain is incloſed in a bony cavity: it occupies the greateſt part of the head, and is anfractuous, and divided into lobes. There is nothing ſimilar to this in the caterpillar;

pillar; we find indeed in the head of that which we are deſcribing, a part which ſeems to anſwer the purpoſe of the brain, becauſe the nerves that are diſſeminated through the head are derived from it; but then this part is unprotected, and ſo ſmall, that it does not occupy one-fifth part of the head; the ſurface is ſmooth, and has neither lobes nor any anfractuoſity: and if we muſt call this a brain, the caterpillar may be ſaid to have thirteen, as there are twelve more ſuch parts following each other in a line; they are nearly of the ſame ſize with that in the head, and of the ſame ſubſtance, and it is from them that the nerves are diſtributed through the whole body. Leſt the idea of thirteen brains might be diſagreeable to his readers, M. Lyonet has called theſe parts ganglions.

The ſpinal marrow in the human ſpecies deſcends down the back, incloſed in a bony caſe; is large with reſpect to it's length, and not divided into branches, diminiſhing in thickneſs in proportion as it is removed further from the brain. In the caterpillar, the ſpinal marrow goes along the belly, is not incloſed in any tube, is very ſmall, forks out at intervals, and is nearly of the ſame thickneſs throughout, except at the ganglions. For a deſcription of the innumerable veſſels, and curious texture of theſe parts, we muſt refer the reader to M. Lyonet's work. The ſubſtance of the ſpinal marrow, and of the ganglions, is not near ſo tender and eaſily ſeparated as in man; it has a very great degree of tenacity, and does not break without conſiderable tenſion. The ſubſtance of the ganglions differs from that of the ſpinal marrow, as no veſſels can be diſcovered in the latter, whereas the former are full of very delicate ones. The patient anatomiſt of the caterpillar has counted forty-five pair of nerves, and two ſingle ones; ſo that there are ninety-four principal nerves, whoſe ramifications are innumerable.

The TRACHEAL ARTERIES of the caterpillar are two large aerial veſſels that creep under the ſkin, cloſe to the ſpiracula, one at the right ſide of the inſect, the other at the left, each of them communicating with the air, by means of nine ſpiracula; they are nearly as long as the body, beginning at the firſt ſpiraculum, and going a little farther than the laſt, terminating in ſome branches, which extend to the extremities of the body.

Round about each ſpiraculum the tracheal artery puſhes forth a great number of branches, which are again divided into ſmaller ones, which further ſubdivide, and ſpread through the whole body of the caterpillar.

The tracheal artery, and it's numerous ramifications, are all open elaſtic veſſels, which may be preſſed cloſe together, or drawn out conſiderably, but return immediately to their uſual ſize when the tenſion ceaſes. They are naturally of a ſilver colour, and have a very beautiful appearance in the microſcope.

This veſſel and it's principal branches are compoſed of three coats, which may be ſeparated one from the other. The exterior covering is a thick membrane, furniſhed with a great number of fibres, which deſcribe a vaſt variety of circles round it, communicating with each other by numerous ſhoots.

The ſecond is very thin and tranſparent; no particular veſſel is diſtinguiſhed in it. The third is compoſed of ſcaly threads, which are generally turned in a ſpiral form, and come ſo near each other as ſcarce to leave any interval; theſe threads are curiouſly united with the membrane which occupies the intervals, and form a tube which is always open, notwithſtanding the flexure of the veſſel. There are alſo many other peculiarities in it's ſtructure, which cannot be well explained without more plates.

The principal tracheal veſſels branch out into 236 ſmaller ones, from which there ſpring 1326 different ramifications.

The part of the caterpillar which naturaliſts call the heart, without being certain that it performs the functions thereof, is of a nature very different from that of larger animals. It is almoſt as long as the caterpillar itſelf, lies immediately under the ſkin at the top of the back, entering into the head, and terminating near the mouth. It is large and ſpacious towards the laſt rings of the body, and diminiſhes very much as it approaches the head, from the fourth to the twelfth diviſion; it has on both ſides, at each diviſion, an appendage, which partly covers the muſcles of the back; but growing narrower as it approaches the lateral line, forms a number of irregular lozenge-ſhaped bodies.

This muſcular tube has been called the heart of the caterpillar; firſt, becauſe it is generally filled with a kind of lymph, which has been ſuppoſed to be the blood of the caterpillar; ſecondly, becauſe in all caterpillars, whoſe ſkin is in ſome degree tranſparent, continual, regular, and alternate dilations and contractions may be perceived along the ſuperior line, beginning at the eleventh ring, and going on from ring to ring to the fourth, whence this veſſel has been conſidered as a file of hearts; but ſtill this viſcera ſeems to have very little relation to the heart of larger animals; we find no veſſel opening into it, to anſwer to the aorta, or vena cava, &c. &c.

Near the eighth diviſion are two white oblong maſſes, that join the tube of the heart; they have been called reniform bodies, becauſe they are ſomething ſimilar to a kidney in their ſhape.

The corpus craſſum is, with reſpect to volume, the moſt conſiderable part of the whole caterpillar; it is the firſt and only ſubſtance that is ſeen on opening it, forming a kind of ſheath, which envelopes and covers all the entrails, and introducing itſelf into the head, enters all the muſcles of the body, filling the greateſt part of the empty ſpaces in the caterpillar. It is of a milk-white colour. In it's configuration it is very ſimilar to the human brain.

When the different maſſes of the corpus craſſum which covers the entrails are removed, the largeſt parts are the oeſophagus, the ventricle, and the large inteſtines.

The oeſophagus deſcends from the bottom of the mouth to about the fourth diviſion. The anterior part which is in the head is fleſhy, narrow, and fixed by different muſcles to the cruſtaceous parts thereof; the lower part, which paſſes into the body, is wider, and forms a kind of membranaceous bag, which is covered with very ſmall muſcles; near the ſtomach it is again narrower, and is as it were bridled by a ſtrong nerve, which is fixed to it at diſtant intervals.

The ventricle begins a little above the fourth diviſion, where the oeſophagus finiſhes, and terminates at the tenth diviſion; it is about ſeven times longer than it is broad; the anterior part, which is the broadeſt, is generally folded.

The folds diminiſh with the bulk, in proportion as it approaches the inteſtines. A great quantity of nerves cover the ſurface, it is ſurrounded by a number of aerial veſſels, and opens into a tube, which M. Lyonet calls the large inteſtine. There are three of theſe large tubes, each of which differs from the others ſo much, both in ſtructure and character, as to require a particular name to diſtinguiſh them; though this is not the place to enumerate theſe characteriſtic differences.

As moſt caterpillars are endowed with a power, or faculty, of ſpinning, they are provided with two veſſels where the ſubſtance is prepared, which, when drawn out, and extended in the air, becomes a ſilken thread; theſe two veſſels are termed the ſilk veſſels, or tubes; in the coſſus they are often above three inches long, and are diſtinguiſhed into three parts, the anterior, the intermediate, and poſterior. The coſſus has alſo two other veſſels, which are ſuppoſed to prepare and contain the liquor by which it diſſolves the wood on which it feeds. Thus have we endeavoured to give the reader an idea of the wonderful organization of this apparently imperfect animal. Aſſuredly, the 4000 * muſcles employed in the conſtruction of the coſſus cannot be conſidered without the deepeſt aſtoniſhment! their admirable coordination and junction with other parts equally numerous, yet all

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* Lyonet ſur la chenille de ſaule, p. 584.

all harmonizing and acting together as if they were eſſentially one, naturally lead the mind to conſider the nature and perfection of the theatre of creation; and to perceive that it is an exhibition of the higheſt wiſdom, and that this wiſdom, which in the minuteſt things gives evidence of ſuch an immenſe attention to order and uſe, has, no doubt, framed the whole for ſome great purpoſe; but what that purpoſe is, we ſhall find it difficult to diſcover.

Though there is no doubt that even this difficulty may be removed, when mankind begin to conſider the univerſe as one connected whole, manifeſting and repreſenting the action of an all-beneficent Creator on his creatures, according to the ſeveral degrees in which they are capable of receiving and diſplaying this action; or, in other words, that this tranſitory ſcene is the ultimate reſult of the ſtate of purity, or error of thoſe intelligences which act thereon. But it would lead us too far from the ſubject in hand, to enter into a diſcuſſion of this truly intereſting ſubject. We muſt, therefore, content ourſelves with recommending the reader to ſtudy nature; with the ſcriptures in his hand, he may be aſſured that he will not only find that they perfectly agree with each other; but he will alſo find, upon an attentive compariſon of paſſages of ſcripture with each other, that thoſe parts which he may have hitherto only conſidered as pleaſing figures, deſcriptive imagery, and perhaps as the ſublime and beautiful of eloquence, have a more diſtinct and cloſe connection with the ſublime and beautiful of nature; that they point out the natural, anatomical, and phyſical relation of the various parts of animated nature with man, and of man with ſuperior intelligences.

He would find that this knowledge was not founded upon the teſtimony of a few obſcure paſſages, but that every word of the ſacred writings, when properly compared with others, will evince that they proceeded from the infinite ſource of wiſdom, and contain ſuch treaſures from that fountain, as ſurpaſs the utmoſt effort of human ability to fathom; and yet that enough is laid open to ſatisfy every real inquirer after truth.

The following character of Mr. Lyonet's work, by M. Bonnet, cannot, I think, but prove agreeable to the reader. I give it in the original, as I am perſuaded it would loſe much of it's genuine force by a tranſlation.

Je propoſerai ici pour modèle à tous les anatomiſtes, ce cèlèbre ſcrutateur de la nature à la ſagacité & au burin duquel nous devons le merveilleux Traité Anatomique de la chenille; ouvrage immortel dont nous n'avions pas même ſoupconnè la poſſibilité, & que je regarde comme la plus belle preuve de fait de l'exiſtence d'une PREMIERE CAUSE INTELLIGENTE. Avec quel plaiſir & quel ettonnement ne lit-on point ces mots à la page xiii. de la Preface: "Comme je ne me ſuis propoſé de publier qu'un ſimple "Traité d'Anatomie, l'on ne doit pas s'attendre à trouver ici de "grand details phyſiologiques; cette partie, ſi pleine d'incer"titudes, pour être expoſée comme il faut, auroit exigè nombre "d'expériences, que la répugnance que j'ai à faire ſouffrir les "animaux, ne m'a pas permis de tenter; répugnance, qui eſt "même allé ſi loin, que j'ai uſé de la plus grande épargne par "rapport à mes ſujets, & que je ne crois point que tout ce traité "ait coûté la vie a plus de huit ou neuf chenilles. Encore ai-je

" eu toujours ſoin de les noyer dans de l'eau avant que de les " ouvrir." Si GELON ſtipuloit pour l'humanite.* Quand il interdiſoit aux Carthaginois vaincus, les ſacrifices humains; LYONET ſtipuloit pour l'animalité quand il tracoit ainſi les devoirs de l'anatomiſte, en ſe peignant ſi naivement lui-même.

## DESCRIPTION OF FIG. 1, PLATE XIII.

### OF THE LEPAS ANATIFERA, OR BARNACLE.

This is a very peculiar ſpecies of ſhell-fiſh; the ſhell is not compoſed of two pieces, or valves, as is the uſual caſe, but of five; two of theſe are larger than the reſt, to which are affixed two ſmaller ones; the fifth piece is long, ſlender, and crooked, running down lengthways, and covering the joinings of the other pieces. It is a tender and brittle ſhell-fiſh, in length about an inch, it's diameter about three quarters of an inch. The ſhell part is of a pale red, variegated with white; it adheres to a neck, or pedicle, of an inch long, and about a fifth of an inch in diameter; by which means it is affixed to old wood, to ſtones, and ſea plants, or any other ſolid ſubſtance that lies under water. It can ſhorten or extend this neck at pleaſure, which reſembles a ſmall gut, and is uſually full of a glarious liquor; it is compoſed of two membranes, an external one, hard and brown, an internal one, ſoft, and of an orange colour. The larger portions of the ſhell open and ſhut in the manner of the bivalves; the others, being moveable by means of their membranous attachments, give way to the opening of theſe, and to the motions of the body of the fiſh, in any direction. It is furniſhed with a cluſter of filaments, placed in a row on each ſide, ſometimes fourteen in number. They are a kind of arms, appropriated for catching it's prey, and therefore placed ſo as to ſurround the mouth of the animal, which is ſituated between them, and conſequently eaſily receives what they thruſt towards it. By the motion of theſe arms, which may be exerted in ſuch a manner, as to play either within or without the cavity of the ſhell, it forms a current of water, which brings with it the prey they feed upon. Fig. 1, Plate XIII. repreſents two of theſe arms, or horns, as ſeen with the microſcope. Fig. 2 repreſents the natural ſize of thoſe from which theſe drawings were made. Each horn conſiſts of ſeveral joints, and each joint is furniſhed on the concave ſide of the arm with a bruſh of long hairs. The arms, when viewed in the microſcope, ſeem rather opake; but they may be rendered tranſparent, and form a moſt beautiful object, by extracting out of the interior cavity a bundle of longitudinal fibres, which runs the whole length of the arm. Mr. Needham * thinks the motion and uſe of theſe arms illuſtrates the nature of that rotatory motion, which ſome writers have thought they diſcovered in the wheel animal.

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* MONTESQUIEU, Eſprit des Loix.

In the midſt of the arms is a hollow trunk, conſiſting of a jointed hairy tube, which incloſes a long round tongue, that the animal can puſh occaſionally out of the tube or ſheath, and retract at pleaſure. The mouth of this animal is ſingular in it's kind, conſiſting of ſix laminæ, which go off with a bend, indented

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* Needham's Microſcopical Obſervations.

dented like a ſaw on the convex edge, and by their circular diſpoſition are ſo ranged, that the teeth in the alternate elevation and depreſſion of each plate act againſt whatever intervenes between them. The plates are placed together in ſuch a manner, that to the naked eye they form an aperture not much unlike the mouth of a contracted purſe.

The weſtern iſles of Scotland, and ſome other parts of the Britiſh dominions, are abundantly ſtored, at certain times of the year, with a bird of the gooſe kind, commonly known in thoſe places by the name of the brent gooſe, or barnacle. Theſe birds rarely breed with us, but ſeek for their ſitting ſeaſon iſlands leſs frequented than thoſe where we find them in common. The ſeeing the birds ſo frequent, and yet never finding any of their neſts, induced ignorant people to believe they never had any, and that they were not bred like other birds.

About the very ſhores where theſe birds are moſt common, the lepas anatifera is alſo found in great abundance. The fiſhermen, who obſerved great quantities of theſe ſhells affixed to rotten wood, or dead trees, that were floating in the water, or lodged by it on the ſhore, were ſoon led to imagine that the filamentous ſubſtances which hung out of them reſembled feathers, and perſuaded themſelves that the geeſe, whoſe origin they could before by no means make out, were bred from them, inſtead of being hatched, like other birds, from eggs.* It was afterwards affirmed, that the ſhells themſelves originally grew on the trees, in the manner of their fruit: and from this aroſe the opinion that the barnacle, or brent gooſe, was the produce of a tree.

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* Hill's Natural Hiſtory of Animals.

## OF THE PROBOSCIS OF THE BEE, FIG. 3 AND 4, PLATE XIII.

The more we penetrate into the hidden receſſes and internal parts of nature, the more we find it marked with perfection in form and deſign. This poſition is ſo clearly proved in the little apparatus we are now about to deſcribe, that Swammerdam,* ſpeaking of it, ſays, that he cannot refrain from confeſſing, to the glory of the immenſe and incomprehenſible Architect, that he had but very imperfectly deſcribed and repreſented this little apparatus; for to repreſent it to the life in it's full perfection, as truly moſt perfect it is, far exceeds the utmoſt efforts of human knowledge.

Soon as the matin glory gilds the ſkies,
Behold the little virtuoſi riſe!
Blithe for the taſk, they preen their early wing,
And forth to each appointed labour ſpring.
Now nature boon exhales the morning ſteam,
And glows and opens to the welcome beam;
The vivid tribes amid the fragrance fly,
And ev'ry art, and ev'ry buſineſs ply.
Each chymiſt now his ſubtle trunk unſheathes,
Where from the flower the treaſur'd odour breathes;
Here ſip the liquid, there ſelect the gum,
And o'er the bloom with quiv'ring membrane hum.
Still with judicious ſcrutiny they pry,
Where lodg'd the prime eſſential juices lie;
Each luſcious vegetation wide explore,
Plunder the ſpring of every vital ſtore:

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* Swammerdam's Book of Nature, p. 195.

The dainty ſuckle, and the fragrant thyme,
By chymical reduction, they ſublime,
Their ſweets with bland attempering ſuction ſtrain,
And curious thro' their neat alembicks drain;
Imbib'd recluſe, the pure ſecretions glide,
And vital warmth concocts th' ambroſial tide.

BROOKE.

By the proboſcis, or trunk, the bee not only procures itſelf neceſſary ſubſiſtence, but it is alſo employed by the animal to collect the honey, which we appropriate to ourſelves as if it was made for us. It may be conſidered in a general view as conſiſting of ſeven pieces; one of theſe, i i, b c, Fig. 3, Plate XIII. is placed in the middle; this is ſuppoſed to be pervious, and to conſtitute what may be properly called the proboſcis. The other ſix ſmaller parts, or ſheaths, diſpoſed in three pairs, are placed on each ſide the former. They not only aſſiſt it in extracting and gathering the honey from the flowers, but they alſo protect and ſtrengthen it. The proboſcis (i i, b c) itſelf is very curiouſly divided; the diviſions are elegant and regular, and are beſet all round with briſtly triangular hairs, diſtributed in an elegant order: theſe diviſions, though very numerous, appear at firſt ſight as a number of different articulations.

The two pieces a a of the exterior ſheath are of a ſubſtance partly between bone and horn, and partly membranaceous; they are ſet round with hairs, and are furniſhed with air veſſels, which are diſtributed through their whole texture; the upper ends f f of this ſheath appear to be a little bent, but can be ſtraitened by the bee when they are applied to the proboſcis. At d d are two articulations, by means of which the pieces a a may be occaſionally bent. The joints contribute towards bending the proboſcis downwards, or rather underneath, againſt the head. Theſe ſheaths, together with the two interior ones e e, aſſiſt in defending, covering, and protecting it from injuries: it is alſo probable that they forward the deſcent of the honey, by preſſing the proboſcis. The parts k k of this ſheath have been called by ſome writers the root.

The two parts e e of the interior ſheath are placed higher than thoſe of the exterior one; they originate at g g on the proboſcis itſelf, and near that part, or articulation, by which the bee can upon occaſion bend the proboſcis; this ſheath, therefore, always moves with the middle part i i, and is carried forward by it, the exterior ſheath being left behind, becauſe it's attachments and origin are below that of the proboſcis. The pieces e e are very ſimilar in ſtructure to thoſe of a a, only that each of them has on the upper part three joints; the lower one is much longer than the other two; they are all of them ſurrounded with ſhort hairs. The ſmaller articulated pieces never lie cloſe to the proboſcis, nor cover it, but are only placed near it, the two upper joints projecting outwards, as in this figure, even when the whole apparatus is ſhut up as much as poſſible. Swammerdam thinks theſe joints are of eſſential uſe to the bee, acting as it were in the manner of fingers, and aſſiſt the proboſcis, by opening the leaves of the flowers, and removing other obſtructions from it: or like the two fore feet of the mole, by the help of which it puſhes the earth from the ſides both ways, that it may be able with it's ſharp trunk to ſearch for it's food more conveniently. There are two ſmaller pieces, or ſheaths, m m, near the bottom of the proboſcis; theſe cannot be well ſeen without removing the ſheath e e.

The proboſcis is partly membranaceous, and partly of a griſtly nature; the lower part is formed in ſuch a manner, that it will ſwell out conſiderably, by which means the internal cavity may be prodigiouſly enlarged, and rendered capable of receiving a very large quantity of native and undigeſted honey, and larger than might be expected from it's ſize. When the proboſcis is ſhut up and inactive, it is very much flattened, and is three or four times broader than it is thick. The edges are always round; it grows tapering, though very gradually, towards the extremity. The lower and membranaceous part of the trunk has no hair on it, but is covered with little protuberant tranſparent pimples, that are placed in regular order, and at equal diſtances from each other, reſembling the little riſings obſervable on the ſkin of birds when the feathers have been plucked off. They are probably glandules, and may have a conſiderable ſhare in changing or preparing the honey that is ſwallowed or taken up by the proboſcis. Down the middle of the proboſcis there is a tube of a much harder nature than the ſides, it grows gradually ſmaller towards the top; at this place the proboſcis is very thick ſet with ſmall hairs; whether they are open tubes, or whether they only ſerve as ſo many claws, to keep it in it's proper place while in action, has not been determined.

The proboſcis terminates in a ſmall cylinder c, at the top of which there is a little globule, or nipple; the circumference of the upper part of this cylinder is beſet with hairs, which radiate from it; the bee can contract this cylindrical part, and the little membrane, in which the hairs are fixed, into a much ſmaller compaſs, and draw it inwards.

The proboſcis is not cylindrical, but rather a kind of convex blade, terminating nearly in a point; and the ſheaths are ſo contrived as to cover little more than the upper part of it; they are a kind of angular groove, of which the upper ſide is the broadeſt. The exterior ſheaths lap over each other on the upper part, ſo that the outſide of the proboſcis is protected by a very ſtrong double caſe, a covering that was unneceſſary for the under part; becauſe when this inſtrument is in uſe the ſheaths are opened, but when it is inactive it is ſo folded that the under part is protected by the body of the bee. Within ſide the exterior ſheath, and near the bottom q, are two levers, which are fixed to the end of the proboſcis, and by which it is raiſed and lowered.

If a bee is attentively obſerved when it has placed itſelf upon a full-blown flower, the activity and addreſs with which it uſes this apparatus will be very conſpicuous. It lengthens the end of it, and applies it to the bottom of the petals, or leaves, of the flower, moving it continually in ten thouſand different ways, lengthening and ſhortening it, bending and turning it in all poſſible directions, to adapt it to the form of the leaves of the flower. Theſe various movements are executed with a promptitude that ſurpaſſes all deſcription.

Mr. Swammerdam thinks that the honey is, as it were, pumped or ſucked up by the bee through the hole at the end b of the proboſcis; he does not ſeem to have diſcovered the apertures which are on the cylindrical part, near the end b.

M. Reaumur thinks it is uſed as a tongue to lap up the fluid which is conveyed down between the ſheath to the mouth of the bee. To prove this, he placed a bee in a glaſs tube, the inſide of which was rubbed over with honey, and little pieces thereof placed in different parts; he obſerved the trunk lying on the honey, the end thereof being ſtretched beyond the honeyed heap; ſhe bends it into the form of a bow, and inſerts the moſt convex part of this bow into the liquor, and then rubs the glaſs backwards and forwards with the ſame ſide of the proboſcis, ſo as very ſoon to clean that part of the glaſs to which ſhe applies it. It is afterwards conveyed to the throat by the various vermicular motions of the proboſcis. Thoſe who wiſh for a fuller account of this curious apparatus, will do well to conſult the intereſting memoirs of M. de Reaumur, who has, with a wonderful ſagacity, diſcovered the principal ſprings of this aſtoniſhing machine. He has there deſcribed more than twenty parts of which it is made, and almoſt given a complete anatomy of this little organ. Like a workman who takes to pieces a watch which he himſelf has made, he lays before us the ſeveral pieces, makes us remark their fitneſs, their adjuſtment, their uſes, the play of their ſprings, pivots, and pillars; for all theſe parts, and many more, are to be found in the proboſcis of the bee.

## OF THE WINGS OF INSECTS.

The attentive obſerver will find a very pleaſing variety of objects in the wings of different inſects. The beauty of their colours, the delicacy of their ſtructure, the art with which they are connected to the body, the curious manner in which ſome are folded up, the admirable texture of their joints, impreſs on the mind a deep ſenſe of that wiſdom, which is manifeſted in ſuch various ways through the whole works of creation.

The delicate tranſparent wings of many inſects are covered and protected by elytra, or caſes, which alſo in ſome meaſure act as wings.—Theſe

"——A two-fold apparatus ſhare,
Natives of earth, and habitants of air;
Like warriors ſtride, oppreſs'd with ſhining mail,
But furl'd beneath their ſilken pennons veil:
Deceiv'd, our fellow reptile we admire,
His bright endorſement, and compact attire;
When lo! the latent ſprings of motion play,
And riſing lids diſcloſe the rich inlay;
The tiſſued wing it's folded membrane frees,
And with blithe quavers fans the gathering breeze.*

The exterior caſes are harder and more opake than the under ones; they are generally highly poliſhed, and often enriched with various colours, adorned with ornamental flutings, and ſtudded with brilliants. All theſe ornaments are united in the curculio imperialis † (or diamond beetle), one of the moſt reſplendent creatures in nature; the head, the wings, the legs, &c. are curiouſly beſet with ſcales of a moſt brilliant view, outvying the ruby, ſaphire, and emerald. It is ſaid, that in the Brazils, from whence they come, it is almoſt impoſſible to look at them on a ſunny day, when they are flying in little ſwarms, ſo great is the glowing glory of their heightened colours.

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* Brooke's Univerſal Beauty.

† Fabricius Spec. Inſ. 184. 129.—Drury. Inſ. 2 Tab. 33. Fig. 1.

The ſtrength and hardneſs of the elytra are admirably adapted to the various purpoſes of the inſects to which they are appropriated, and at the ſame time that they protect the tender wing, they ſerve as a ſhield to the body; the ribs, and other prominencies, on many of them, contribute to leſſen the friction, and diminiſh the preſſure to which they are often expoſed.

In moſt of theſe inſects the under wing is longer and larger than the exterior one, ſo that it is obliged to be bent and folded up, in order to lie under the elytra; for this purpoſe they are furniſhed with ſtrong muſcles, and proper articulations, to diſplay and conceal them at pleaſure. Fig. 2, Plate XIV. repreſents the wing of the earwig* when unfolded, and of it's natural ſize. Fig. 1 repreſents it as exhibited by the microſcope. We ſhall deſcribe this more particularly hereafter.

We have already treated of thoſe decided differences in the wings of inſects, which aſſiſt the natural hiſtorian in ranging them into claſſes; ſo infinite are the varieties to be obſerved in this curious organ, that only to enumerate them would occupy many pages; we muſt, therefore, content ourſelves with a few general remarks, leaving it to ſome future writer to diſplay the wonders that are manifeſted in their diſpoſition, ſtructure, motions, and ornaments. In general, the wings are delicate and yet ſtrong, furniſhed with ribs, or nerves, curiouſly inoſculated

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* Forficula auricularia, Lin. Syſt. Nat. vol 1, part 2, 686-1.

together, ſo as to ſtrengthen and convey nouriſhment to the ſeveral parts of the wing, while by the diverſity of their ramifications they add to it's beauty; many have their wings fortified with briſtly hairs, which they can erect at pleaſure, Plate XV. Fig. 1.

The wings of the moth and butterfly are moſtly farinaceous, being covered with a fine duſt, which renders them opake, and is alſo the cauſe of thoſe beautiful and variegated colours which ſo richly adorn them; that

> "Not all the ſhew and mockery of ſtate,
> The little, low, fine follies of the great;
> Not all the wealth which eaſtern pageants wore,
> What ſtill our idolizing worlds adore,
> Can boaſt the leaſt inimitable grace
> Which decks profuſive this illuſtrious race."

Ever ſince the microſcope was invented, this duſt has engaged the attention of the microſcopic obſerver. For by this inſtrument it is found to be a regular aſſemblage of organized ſcales, of various ſhapes and colours, ſome long and ſlender, ſome ſhort and broad, ſome notched at the edges, others ſmooth, generally furniſhed with a kind of foot ſtalk, by which they are fixed to the wing, ſee Fig. E F H I, of Plate XVI. Their ſhapes are not only very different in moths of various ſpecies, but of thoſe on the ſame moth ſome will be found to be nearly oval, while others are triangular; a variety of large ſtripes, or ribs, are to be diſcovered in theſe ſcales, and between theſe larger ramifications minuter lines may be ſeen; the larger ſtripes ſeem in general to riſe from the exterior notches; ſome of theſe ſcales, or plates, are to be found ſo exceedingly ſlender, that it is not eaſy to diſcriminate them from hairs by the naked eye. The regular arrangement of theſe plates, one beſide, and partly covering the other, as in the tiling of a houſe, is beſt ſeen by examining the wing in the opake microſcope. The prodigious number of ſmall ſcales which cover the wings of theſe beautiful inſects, is a ſure proof of their utility to them, becauſe they are given by HIM who makes nothing in vain.

That the lively and variegated colours which adorn the wings of the moth and butterfly ariſe from the ſmall ſcales, or plates, that are planted therein, is very evident from this, that if they are bruſhed off from it, the wing is perfectly tranſparent; but whence this profuſion and difference of colour on the ſame wing? is a queſtion as difficult to reſolve as that of Prior, when he aſks,

"Why does one climate and one ſoil endue
The bluſhing poppy with a crimſon hue,
Yet leave the lilly pale, and tinge the violet blue?"

The materials of the wings under theſe plates ſeem to be of a talcy nature; the wing is ſtrengthened by ſeveral nerves, or ribs, which run through it; the largeſt fortifies the exterior edge of the wing, while a ſmaller one ſtrengthens the interior edge. When the moth immerges from the chryſalis, the wings are ſoft and thick, and if they are examined at that time, they will be found to conſiſt of two membranes, which may be raiſed up, and then ſeparated, by blowing between them with a ſmall tube. The veſſels, or ribs, lie between theſe ſkins.

As the wings of the moth and butterfly are light, they can ſupport themſelves for a long time in the air; their manner of flying is ungraceful, mounting and deſcending alternately, ſo that they generally move in a zigzag line, to the right and to the left, up and down; by this means they often eſcape the birds who chace them, as this undulating motion diſappoints them in their aim: hence they often may be ſeen to purſue a butterfly in vain for a conſiderable time.

Dr. Hooke * endeavoured to inveſtigate the nature of the motions of the wings of inſects; and although he was not able, from the experiments he made, to give a ſatisfactory account of them, yet as they may be uſeful to ſome future inquirer, and lead him more readily into the path of truth, I hope an extract therefrom will not prove unacceptable to the reader. To inveſtigate the mode or manner of moving their wings, he conſidered with attention thoſe ſpinning inſects that ſuſpend, or as it were poiſe themſelves, in one place in the air, without riſing or falling, or even moving backwards or forwards; by looking down on theſe he could, by a kind of faint ſhadow, perceive the utmoſt extremes of the vibratory motion of their wings; the ſhadow, while they were thus ſuſpended, was not very long, but was lengthened when they endeavoured to fly forwards. He next tried, by fixing the legs of a fly upon the top of the ſtalk of a feather, with glue, wax, &c. and then making it endeavour to fly away; he was thereby

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* Hooke's Micrographia, p. 172.

thereby able to view it in any poſture. From hence he collected, that the extreme limits of the vibrations were uſually ſomewhat about the length of the body diſtant from each other, often ſhorter, and ſometimes longer. The foremoſt limit was generally a little above the back, and the hinder one ſomewhat beneath the belly; between theſe, to judge by the ſound, they ſeemed to move with an equal velocity. The manner of their moving them, if a juſt idea can be formed by the ſhadow of the wing, and a conſideration of it's nature and ſtructure, ſeemed to be this: the wing being ſuppoſed to be in the extreme limit, it is then nearly horizontal, the fore part only being a little depreſſed; in this ſituation the wing moves to the lower limit; before it arrives at this, the hinder part begins to move faſteſt; the area of the wing begins to dip behind, and in that poſture it ſeems to be moved to the upper limit back again. Theſe vibrations (judging by the ſound, and comparing them with a ſtring tuned in uniſon thereto) conſiſt of many hundreds, if not thouſands, in a ſecond of time. The powers of the governing faculty of the inſect, and the vivacity of it's ſenſations, whereby every organ is ſtimulated to act with ſo much velocity and regularity, ſurpaſs our preſent comprehenſion.

Fig. 1, Plate XV. is a repreſentation of the wing of the hemerobius perla (Lin. Syſt. Nat. vol. 1, part 2, page 911-2) of the natural ſize. Fig. 2 repreſents the ſame wing magnified. This elegant inſect has acquired the name of hemerobius from the ſhortneſs of it's life, as it ſeldom lives more than two or three days in it's fly ſtate: Linnæus has placed it in his fourth claſs, among thoſe inſects which have four tranſparent wings and no ſting. The wings are nearly of a length, and exactly ſimilar;

they are compoſed of delicate fine nerves, regularly and elegantly diſpoſed, as may be ſeen in the figure; they are beautifully adorned with hairs, and are ſlightly tinged with green. The body is of a fine green colour, and it's eyes appear like two delicate beads of burniſhed gold, from whence it is by many called the golden eye. This curious little inſect lays it's eggs on the leaves of the plumb, roſe tree, &c. the eggs are ſmall and white, and each of them fixed to a little pedicle, or foot ſtalk, about half an inch long; they ſtand off from the leaf, and appear much like the fructification of ſome of the moſſes. This ſingular circumſtance has been already noticed in page 265 of theſe eſſays. The larva which proceed from theſe eggs reſemble that of the coccinella, or lady cow, but are much handſomer; it feeds like them on the aphides, or pucerons, ſucking their blood, and forming itſelf a caſe with their dried bodies, in which it changes into the pupa ſtate, from whence they afterwards immerge in the form of the fly here deſcribed.

Fig. 2, Plate XIV. repreſents the wing of the forficula auricularia, or earwig, (Linn. Syſt. Nat. vol. 1, part 2, page 686-1) of the natural ſize. Fig. 1, the ſame wing magnified. Though this inſect is ſo very common, yet few people know that they have wings, and fewer yet have ſeen them; they are of a curious and elegant texture, and wonderful ſtructure. The upper part is cruſtaceous and opake, while the other part is beautifully tranſparent. It folds up into a very ſmall compaſs, and lies nearly concealed under the elytra, which are not more than a ſixth part of the wing in ſize. They firſt fold back the parts A B, and then ſhut up the ribs like a fan; the ſtrong muſcles uſed for this purpoſe are ſeen at the upper part of the figure. The ribs are extended from the center to the outer edge, others are extended only from the edge about half way, but they are all united by a kind of band, at a ſmall but equal diſtance from the edge; the whole evidently contrived to ſtrengthen the wing, and facilitate the various motions thereof. The earwig is a very deſtructive animal, doing conſiderable injury to moſt kinds of wall fruit, to carnations, and other fine flowers, &c. and as they only feed in the night, they eſcape the ſearch of the gardener. Reeds open at both ends, and placed among fruit trees, are a good trap for them, as they croud into theſe open channels, and may be blown out into a tub of water. As they conceal themſelves in the day-time, thoſe that are curious in flowers place tobacco pipes, lobſters claws, &c. on the top of their garden ſticks, in order to catch them. This inſect differs very little in appearance in it's three different ſtates. De Geer aſſerts, that the female ſits on her eggs, and broods over the young ones as a hen does over her eggs.

## OF THE EYES OF INSECTS.

The conſtruction and formation of the eyes of inſects differs conſiderably from that of other animals. In other creatures the eyes are moveable, and generally placed one on each ſide of the head, and two are ſufficient for all the purpoſes of viſion. But in inſects the eyes are fixed, and therefore would not ſerve to give them a view of any object but what was placed directly before them. We therefore find that they are provided with a number of eyes, which in ſome ſpecies, as in the ſpider, are ſingle, and placed at ſome diſtance from each other. But the greater part are furniſhed with a collection of an indefinite number of very ſmall ſingle eyes, placed in one common caſe or ſocket.

The two protuberances on the head, which are formed by this congeries of eyes, ſeem to the naked eye to conſiſt of a number of lines, croſſing with great regularity and exactneſs, at ſome little diſtance from each other, like the meſhes of a net, from whence they have been termed the reticular eyes. Thoſe of the libellula are peculiarly well adapted, on account of their ſize, for a microſcopic view of this ſubject. Theſe eyes are ſo perfectly ſmooth and poliſhed, that when viewed as an opake object, they will, like ſo many mirrors, reflect the images of all the ſurrounding objects. The figure of a candle may be ſeen multiplied almoſt to infinity on their ſurfaces, ſhifting it's beam to each eye according to the motion given it by the obſerver's hands. Other animals are obliged to turn their eyes towards any object, but theſe have eyes ready directed to it, on whatever ſide it may preſent itſelf. The genus of cancri have their eyes moveable, but for the moſt part reticulated like other inſects.

Though the reticulated eyes of flies are large, not only in proportion to the ſize of the creature, but abſolutely and in themſelves; yet the ſeveral ſmall eyes, of which they are compoſed, are remarkably minute in compariſon of thoſe of the butterfly claſs.

Moſt of the butterfly claſs have in each of their reticulated eyes many thouſand ſmall ones; but the fly claſs greatly exceed them in the number of theſe, as many of their eyes are three times as large as thoſe of the butterfly, and beſides that each ſmaller eye is vaſtly more minute.

Mr. Hook computed 14,000 hemiſpheres in the two eyes of a drone; Mr. Leeuwenhoeck reckoned 6236 in a ſilk-worm's two eyes in it's fly ſtate; 3181 in each eye of a beetle, and 8000 in the two eyes of a common fly. The pearl eyes of the dragon fly appear with a common reading-glaſs like ſhagreen, and Mr. Leeuwenhoeck reckoned in each eye of this inſect 12,544 lenſes, placed in an hexangular poſition, each lens having ſix others round it. He alſo obſerved in the center of each lens a minute tranſparent ſpot, brighter than the reſt, ſuppoſed to be the pupil, ſurrounded with three circles, and in appearance ſeven times leſs than the diameter of the whole lens. Mr. Puget counted 17,325 in the eye of a butterfly, which Malphigi concludes to be diſtinct and ſeparate eyes. The Abbé Catalan, and others, have ſince ſhewn, that all the eminences diſcoverable in the cornea of inſects have the neceſſary parts, and perform the offices of an eye. Leeuwenhoeck diſcovered the bundles of optic nerves which ſerve theſe ſmall lenſes; and Reaumur ſuppoſes that theſe ſupply the place of all that is wanted behind the lenſes, for the organization of an eye complete for viſion.

But it is in the works of Swammerdam that we are enabled to contemplate the aſtoniſhing organization of the eyes of inſects. Under each meſh, or facet, there is a little pyramid of fibres, broad at the baſe, and growing ſmaller as it proceeds inwards. The pyramids have the ſame number of ſides as each eye, and there are, therefore, as many hexagonal pyramids as there are ſmall facets, or eyes, in the inſect. An innumerable quantity of pulmonary tubes aſcend theſe fibres; theſe tubes terminate in a fine tranſparent white fibrous membrane, of a convex ſhape, which is alſo thick ſet with pulmonary tubes; under this membrane is another, which is more delicate and more tranſparent, but connected with it by means of pulmonary tubes; under this there is placed a ſecond ſpecies of fibres, tranſverſely applied, like ſo many beams, to ſupport the pyramidal fibres that are laid over them.

Each ſide of the head of a fly, which is cut as it were into a multitude of ſmall facets, is one of the reticulated eyes of the creature. Nature allots two of theſe reticulated eyes to each fly; and as they each contain ſuch a vaſt multitude of ſmaller, but perfect eyes, one would imagine them to be very ſufficient for all the occaſions of the animal. There are, however, certain flies of the ephemera kind which have four of theſe reticulated eyes, two of which are placed as is uſual in the muſca, and are but of ſmall extent; the other two have each the appearance of a ſort of turban, and are placed one beſide the other upon the upper part of the head.

Theſe have ſomewhat the figure of a muſhroom, the head of it extended a little beyond the ſtalk, and the upper convex ſurface cut into almoſt an innumerable quantity of facets.

The firſt pair of the reticular eyes of this fly, which are placed as thoſe of the other flies, are in colour brown; thoſe of the muſhroom form are of a very beautiful citron-colour, and as tranſparent as the moſt pellucid reticular eyes of other flies; for, among the various ſpecies, ſome have theſe eyes much more tranſparent than others. The fly, thus remarkably furniſhed with eyes, is produced from a worm of the ſame kind with the common ſpecies of ephemerons; it's body is of a pale yellow, and it's wings white; the two inferior ones of theſe are ſo ſmall, that they are not eaſily diſtinguiſhed.

Among the fly claſs theſe reticular eyes are, in different ſpecies, of different colours; there are ſome which have them brown, others yellow, others green, and others red, and this in all the different ſhades of thoſe colours. Some of them have alſo the gloſs of metals highly poliſhed, others afford us a view of changeable colours, and others have arrangements of different colours, fixed and invariable. The eyes of one ſpecies of the gad-fly, ſo troubleſome to oxen, have ſtreaks of red, green, and brown, placed alternately.

One would imagine, that as every fly has two of theſe reticular eyes, each compoſed of ſuch a multitude of real eyes, they could have no occaſion for any more; but ſo it has not appeared to the great Being that formed them, for many ſpecies are furniſhed with more eyes, which differ both in conſtruction and form from thoſe that are reticulated.

The eyes already deſcribed are properly called reticular ones; and to avoid confuſion, it will be neceſſary to deſcribe thoſe which differ from them by ſome determinate name (they are now generally termed the ſtemmata); theſe, when examined by the beſt microſcopes, appear of a perfectly ſmooth, gloſſy, and poliſhed ſurface, but plain and ſimple, without the leaſt appearance of a reticulated texture. They are alſo much ſmaller than the reticulated eyes, and may therefore be called, by way of diſtinction, the ſmaller ſmooth eyes, or the ſtemmata.

M. De la Hire ſeems to have been the firſt perſon who diſcovered theſe ſmooth eyes. He obſerved three of them diſpoſed in a triangular form, on the back part of the heads of ſome of theſe little creatures. He ſoon found that they were tranſparent, and thence naturally judged them to be of the ſame nature of the cornea of our eyes, and really to ſerve the ſame office to the creature poſſeſſed of them.

We find three of theſe ſmooth eyes placed triangularly on the back part of the head of vaſt numbers of the genera of flies, as well of the two-winged as of the four-winged kinds; but there are alſo ſome of both theſe claſſes, in which they are wanting. All the ſpecies of gnats, and of tipulæ, are without them. The heads of theſe are very ſmall in proportion to the bulk of their body, and are in a manner covered by their reticular eyes. The want of the ſmall eyes is amply made up by the ſize and extent of the larger; but there are ſome other kinds which want them, without having this advantage in their place. Of the two-winged flies with ſhort bodies, the gad-flies want theſe eyes; and among the longer bodied and four-winged kinds, the flies produced from the puceron-eaters (hemerobius).

Notwithſtanding, therefore, that many ſpecies of flies have theſe eyes, there are yet ſo many that want them, that Mr. De la Hire would not have judged theſe to be their only eyes, if he had made experiments on the reticulated ones, in the manner of Meſſ. Swammerdam and Reaumur. Mr. Swammerdam put upon the eyes of certain flies a covering of black, ſteeped in oil; in this ſtate they flew at random, and ſeemed to have no ſtrength; and wherever they ſettled they did not avoid the hand which would take them. M. Reaumur made alſo ſome experiments upon the reticulated eyes of bees, which were all taken from the ſame hive. He ſpread upon them a covering of dark-coloured varniſh, and ſhut them up with ſome of their companions which had not been touched, in a large powder-box. At about eight or ten ſteps from the hive from whence they were taken, the cover of the box was taken off; thoſe which had their eyes clear immediately took their flight, and went to their habitation; thoſe whoſe eyes were varniſhed made no haſte to get out of the box; they had ſome difficulty to determine themſelves for flight, and the greateſt number directed it at random, and on different ſides, and went not far. To oblige ſome of them to fly farther, they were thrown into the air; they raiſed themſelves vertically till they were loſt, and not one of them ſeemed to know the way to it's hive.

To know what would happen if the ſtemmata were covered, he put varniſh upon them, in the ſame manner as was done to the reticulated eyes, and ſet them likewiſe at liberty, about three or four ſteps from the hive; not one ſeemed to know it's way, or even ſeek it. They flew on all ſides upon the plants, but did not fly far.

An inſect is, I believe, never found with both kinds of eyes but when it is in it's perfect ſtate. The moth, for inſtance, which has ſeveral thouſands of eyes in the reticulated form, has only ſix ſmall ſmooth eyes in the ſtate of the caterpillar. The wonderful anatomiſt of the coſſus has ſhewn, that the eyes of the latter are in the form of a cup, and that the cornea, which is the cover to this cup, is very tranſparent. He has been enabled to diſcover a true optic nerve, that divides into ſix branches, which are connected with each eye; each of theſe is accompanied with a pulmonary tube. This celebrated obſerver, in ſpeaking lightly of the reticulated eyes of the moth of the coſſus, which are in number 22,000, ſays, that each is probably a teleſcope, conſiſting at leaſt of three lenſes.

It is eaſy to ſhew with the eye of a fly, prepared as we have already deſcribed in page 142, chapter iv. and then placed before the microſcope, that each of the portions of theſe reticular eyes have the power of refracting the light, and forming an image of a candle, or any other object, at their reſpective foci. Mr. Martin affirms, that in a great number of obſervations he always found that the edge of the cornea of each eye was always thicker in the middle than at the edges, and that this ſwelling out, or increaſe of thickneſs, was equal on each ſide, and exactly oppoſite, amounting to a full proof that the cornea of an inſect's eye is really a ſyſtem of a great number of exceeding ſmall double and equally convex lenſes, of an hexagonal form, "and affording one of the moſt ſtriking inſtances of Divine geometry and optics."

Fig. 3, Plate XVI. is a repreſentation of a ſmall portion of the cornea of the libellula, as ſeen by the microſcope. The ſides of the hexagons, in ſome poſitions of the light, appear of a fine gold colour, and divided into three parallel lines. Fig. 4 is the ſame piece of it's natural ſize.

Fig. 5, Plate XVI. repreſents a piece of the cornea of a lobſter's eye; in theſe each of the eyes are ſet as it were in a ſquare frame. Fig. 6, the ſame piece not magnified.

Mr. William André has ſhewn, that theſe are not the only variations which are to be found in the eyes of theſe ſmall creatures; for thoſe of the monoculus polyphemus are made up of a great number of ſmall tranſparent amber-like cones. See his letter to Sir Joſeph Banks, in the Philoſophical Tranſactions, a ſhort extract from which I ſhall proceed to lay before the reader.

" The monoculus polyphemus, or king crab, is a cruſtaceous animal, found in all the ſeas ſurrounding the continent of America and the Weſt India iſlands, and which frequently grows to a very large ſize.

" If the ſhell of the monoculus were divided fairly in half, the large eyes would be nearly in the center of each piece, and the ſmall ones on the divided edge, near the fore-part of the ſhell. The large eyes are at a great diſtance from each other; but the ſmall ones are cloſe together. It will appear hereafter that the large eyes are made up of a great number of ſmall tranſparent amber-like cones, and that the ſmall ones are compoſed of one ſuch cone only; ſo that they may be divided into eyes with many cones, and eyes with a ſingle cone. The large eyes, or thoſe with many cones, appear as two tranſparent ſpots, about the ſize and nearly of the ſhape of a kidney-bean, the concave edges looking towards each other, and the convex towards the edge of the ſhell. If they be examined attentively, we may diſcern on their ſurface a number of ſmall depreſſions, which point out the center of each cone. The ſmall eyes, or thoſe with a ſingle cone, look like two ſmall tranſparent ſpots, not larger than a pin's head; theſe, from their minuteneſs, are eaſily overlooked.

"The appearances which have been deſcribed may be ſeen on the external ſurface of the ſhell with the naked eye; but in order to proceed to a further inveſtigation of the ſubject, the cornea muſt be removed from the ſhell, and applied to a ſingle microſcope with a very ſtrong light.

"The internal ſurface of the large eyes, examined with the microſcope, is found to be thick ſet with a great number of ſmall tranſparent cones, of an amber colour, the baſes of which ſtand downwards, and their points upwards next the eye of the obſerver. The cones in general have an oblique direction, except ſome in the middle of the cornea, about thirty in number, the direction of which is perpendicular.

"The center of every cone being the moſt tranſparent part, and that through which the light paſſes, on that account the perpendicular or central cones always appear beautifully illuminated at their points. In a word, they are all ſo diſpoſed, as that a certain number of them receive the light from whatever point it may iſſue, and tranſmit it to the immediate organ of ſight, which we may reaſonably ſuppoſe is placed underneath them; the cones are not all of the ſame length; thoſe on the edges of the cornea are the longeſt, from whence they gradually diminiſh as they approach the center, where they are not above half the length of thoſe on the edges."

## OF THE INSECT WHICH IS REPRESENTED AT FIG. 1, 2, 3, PLATE XVII.

This very beautiful and ſingular inſect was firſt pointed out to me by Mr. Marſham, who had ſeen it in the cabinet of inſects belonging to the Queen, in the royal obſervatory at Richmond. Her Majeſty was pleaſed to permit me to have the drawing taken from it, from which this plate was engraved. When Mr. Marſham firſt ſaw it at Richmond, he conſidered it as an undeſcribed inſect, and an unique in this country. But he has ſince found that it is mentioned by Fabricius, in his Syſtema Entomologiæ, as a new genus, under the name of leucoſpis dorſigera; and there is one of the inſects in the cabinet of the celebrated Linnæus, now in the poſſeſſion of J. E. Smith, M. D. F. R. S. Sulz, and other writers, have alſo deſcribed it.

It appears at firſt ſight like a waſp, to which genus the folded wings would have given it a place, had not the remarkable ſting, or tube, on the back removed it from thence. It is probably a ſpecies between, and uniting the ſphex and waſp, in ſome degree partaking of the characters of both. The antennæ are black and cylindrical, increaſing in thickneſs towards the extremity; the joint neareſt the head is yellow, the head is black, the thorax is alſo black, and encompaſſed round with a yellow line, and furniſhed with a croſs one of the ſame colour, near the head. The ſcutellum is yellow, the abdomen black, with two yellow bands, and a ſpot of the ſame colour on each ſide between the bands. A deep black poliſhed groove extends down the back, from the thorax to the anus, into which the ſting turns and is depoſited, leaving the anus very circular; a yellow line runs on each ſide the ſting. The anus and the whole body, when viewed with a ſhallow magnifier, appear punctuated; theſe points, when examined in the microſcope, appear hexagonal, as in the plate; and in the center of each hexagon a ſmall hair is to be ſeen; the feet are yellow, the hinder thighs very thick and toothed, and alſo form a groove for the next joint; they are yellow, with black ſpots: it is found in Italy, Switzerland, France, and Germany. Fig. 1, Plate XVII. ſhews it very much magnified. Fig. 2 is a ſide view of it, leſs magnified. Fig. 3 is the object of it's real ſize.

## OF THE LOBSTER INSECT, DELINEATED FIG. 1 AND 6, PLATE XVIII.

This extraordinary little creature was found by my ingenious friend, Mr. John Adams, of Edmonton; he was at the New Inn, Waltham Abbey, where it was ſpied by ſome labouring men who were drinking their porter. The man who firſt perceived it thought it was of an unuſual form; this occaſioned a nicer inſpection, and it was ſuppoſed to be a louſe with unuſual long horns; others thought it was a mite. This occaſioned a debate, which drew the attention of my friend, who obtained the inſect from them for further obſervation. Mr. Martin has given ſome account of it in the third volume of "The Young Gentleman and Lady's Philoſophy." Mr. Adams favoured me with the inſect, that an accurate drawing might be taken from it, which I thought would be highly pleaſing, not only to the lovers of microſcopic obſervations, but alſo to the entomologiſt. It appears to be quite a diſtinct ſpecies from the phalangium cancroides of Linnæus, of which a good drawing has been given by Hook, Roeſel, Schæffer, &c. it has alſo been deſcribed by Scopoli, Geoffroy, &c.; not one, however, of theſe deſcriptions agrees with the animal under conſideration. The abdomen of this is more extended, the claws are larger and much more obtuſe, the body of the other being nearly orbicular, the claws ſlender, and finiſhing almoſt in a point, more tranſparent, and of a paler colour. It is very probable that there are ſeveral ſpecies nearly ſimilar. Mr. Marſham has two in his poſſeſſion, one like the drawings of Reaumur, the other not to be diſtinguiſhed from that which is repreſented in Plate XVIII. except that it wants the break, or dent, in the claws, which is ſo conſpicuous in this. He found his firmly fixed by it's claws to the thighs of a large fly, which he caught on a flower in Eſſex the firſt week in Auguſt, and from which he could not diſengage it without great difficulty, and tearing off the fly's leg, which he did on a piece of writing paper, and was much ſurprized to ſee the little creature ſpring forwards full a quarter of an inch, with great impetuoſity, and again ſeize it's prey, from which he had great trouble to diſengage it.

## OF FIG. 3, 4, AND 5, PLATE XVIII.

The inſect which is repreſented at Fig. 3, Plate XVIII. was originally named phyſapus by Mr. de Geer, on account of the bladders at the feet. Linnæus terms it trips.

They live upon plants, and particularly in flowers. The one figured here is the black trips, with white wings; the antennæ have ſix articulations, the body is black, the wings whitiſh, long and hairy, the head ſmall, with two large reticular eyes. The antennæ are of an equal ſize throughout, and divided into ſix oval pieces, which are articulated together. The extremities of the feet are furniſhed with a membranaceous and flexible bladder, which it can throw out or draw in at pleaſure. It places and preſſes this bladder againſt the ſubſtances on which it is walking, and ſeems to fix itſelf thereby to them; the bladder ſometimes appears concave towards the bottom, the concavity diminiſhing in proportion as it is leſs preſſed.

They have four wings, two upper and two under ones; theſe laſt are with great difficulty perceived; they are fixed to the upper part of the breaſt, laying horizontally; both of them are rather pointed towards the edges, and have a ſtrong nerve running round them, which is ſet with a hair fringe, tufted at the extremity. The wings are repreſented by themſelves at Fig. 4; the inſect of the real ſize at Fig. 5. They are to be found in great plenty in the ſpring and ſummer, in the flowers of the dandelion, &c.

### OF FIG. 2, PLATE XVIII.

This beautiful opake object is a piece of the ſkin of the lump fiſh. For a full deſcription of this ſingular creature, I muſt refer the reader to Pennant's Britiſh Zoology, vol. iv. page 117. There are no ſcales on the body, but a greater number of theſe tubercles, which are exhibited in this figure. When a good ſpecimen is procured, it forms a moſt delightful object for the opake microſcope. It is probable that the fiſh exudes an unctuous matter from theſe tubercles.

Fig. 1, Plate XX. is a beautiful inſect of the hemiptera claſs, or that kind where the elytra are only in part cruſtaceous, and which do not form a longitudinal ſuture down the back, but fold over about one-third of their length towards the bottom, where it is alſo partly tranſparent. It is of the genus cimex, and called ſtriatus by Linnæus. It cannot boaſt a variety of colours, though what it has are bright and elegantly diſpoſed: the head, proboſcis, and thorax, are black. The thorax is ornamented with yellow ſpots, the middle one large, and occupying almoſt one-third of the poſterior part; the other two are on each ſide, and triangular. The ſcutellum has two yellow oblong ſpots, pointed at each end; the ground of the elytra is a bright yellow, ſpotted and ſtriped with black. The nerves are yellow, and there is a brilliant triangular ſpot of orange, which unites the cruſtaceous and membranaceous parts; the latter is brown and clouded. The feet are of a fine red, and the rings of the abdomen are black, edged with white. This pretty inſect is to be found in June, upon the elm-tree. It is repreſented at A of the natural ſize.

## PLATE XX. FIG. 2.

A very common, though elegant, inſect of the coleoptra claſs, is repreſented as ſeen in the lucernal microſcope, and of it's natural ſize at B; it is called by Linnæus chryſomela aſparagi, from the larva feeding on the leaves of that plant. It's figure is oblong, the antennæ black, compoſed of many joints nearly oval. The head is a bright but deep blue, the thorax red and cylindrical, the elytra blue, with a yellow margin, with three ſpots of the ſame colour on each, one at the baſe of an oblong form, and two united with the margin; the legs are black, but the under ſide of the

the belly is of the ſame blue colour with the elytra and head. This little animal, when viewed by the naked eye, ſcarcely appears to deſerve any notice; but when examined by the microſcope, it is one of the moſt pleaſing opake objects we have.

This inſect is found in June, on the aſparagus aſter it has run to ſeed. De Geer ſays, that it is very ſcarce in Sweden.

## FIG. 3, PLATE XX.

The inſect which comes at preſent under our inſpection is peculiarly adapted to ſhew the advantages of the microſcope, which alone will diſcover the peculiarities of it's figure; this is ſo remarkable, that the naturaliſts appear undetermined as to it's genus. Geoffroy formed a new one for it, under the title of notuxus, in which he has been followed by Fabricius; even Linnæus himſelf could not determine at firſt where to place it, for in the Fauna Suecica he makes it an attelabus, but in the laſt edition of the Syſtema Naturæ he has fixed it as a meloe, calling it the meloe monoceros; but ſtill he adds, "genus difficile determinatur forte huic proximum." Both Geoffroy and Schæffer have given figures of it, but as they had not that kind of microſcope which would aſſiſt them, their figures are imperfect.

The head is black, and appears to be hid, or buried, under the thorax, which projects forwards like a horn; the antennæ are compoſed of many articulations, and with the feet are of a dirty yellow. The hinder part of the thorax is reddiſh, the fore-part black. The elytra are yellow, with a black longitudinal line down the ſuture; there is a band of the ſame colour near the apex, and alſo a black point near the baſe; the whole animal is curiouſly covered with hair. Geoffroy ſays it is found on umbelliferous plants; the one here deſcribed was found in May; the natural ſize is ſeen at C.

Fig. 1 and 3, Plate XIX. repreſents two of the feet of the monoculus apus of Linnæus. They are curiouſly contrived to aſſiſt the animal in ſwimming, and form a very beautiful object for the microſcope.

Fig. 2 and 4 are of the natural ſize.

## OF THE SCALES OF FISH.

The outſide coverings, or ſcales, of fiſhes afford an immenſe variety of beautiful objects for the microſcope. They are formed in the moſt admirable manner, and arranged with inconceivable beauty and regularity; ſome are of a long ſhape, others nearly round, ſome ſquare, varying in ſhape, not only in different ſpecies of fiſh, but even conſiderably on the ſame fiſh; thoſe which are taken from one part not being entirely ſimilar to thoſe which are taken from another.

Leeuwenhoeck ſuppoſed each ſcale to conſiſt of an infinity of ſcales, laid one over the other, or more ſimply of an infinity of ſtrata, of which thoſe next the body of the fiſh are the largeſt.

Theſe ſtrata exhibit a ſpecimen of very beautiful workmanſhip; when viewed with the microſcope, we find them to be conſtructed with wonderful art. In ſome ſcales we diſcover a prodigious number of concentric flutings, too fine, as well as too near each other, to be eaſily enumerated; they are probably formed by the edges of each ſtratum, denoting the limits thereof, and the different ſtages of the growth of the ſcale. Theſe flutings are often traverſed by others that proceed from the center of the ſcale, which is ſeldom in the middle thereof; theſe generally go in a ſtrait line from this center to the circumference.

Fig. 7, Plate X. repreſents a ſcale from a ſpecies of the parrot fiſh of the Weſt-Indies, conſiderably magnified. Fig. 8, the real ſize of the ſcale.

Fig. 9, Plate X. is a ſcale of the ſea perch, which is found on the Engliſh coaſt.

Fig. 10, the ſame ſcale of the natural ſize.

Fig. 7, Plate XIX. a ſcale from the haddock, as ſeen in the microſcope. Fig. 8, the ſame of the natural ſize.

Fig. 9, Plate XIX. a ſcale from a ſpecies of perch from the Weſt-Indies, magnified. Fig. 10, the ſcale of it's real ſize.

Fig. 11, a ſcale from the ſoal-fiſh, delineated as it appeared in the microſcope; the pointed part is that which ſtands without the ſkin, as may be ſeen in Fig. 5, which repreſents a piece of the ſkin of the ſoal, as viewed by the opake microſcope. Fig. 6 and 12, the ſame objects of their real ſize.

CHAP.

# CHAP. VII.

## THE NATURAL HISTORY OF THE HYDRA, OR FRESH-WATER POLYPE.

THE polypes deſcribed in this chapter are freſh-water inſects, of the genus of hydra, in the claſs of worms, and order of zoophytes. When they are cut or divided into a number of pieces, the ſeparated parts in a very little time become ſo many perfect and diſtinct animals; each piece having a power of producing a head, a tail, and the other organs neceſſary for it's life and ſtate.

They are generally known by the name of polype; but as this was thought by many to be improper, becauſe that, ſtrictly ſpeaking, they have no feet, Linnæus called the genus hydra, probably from their property of reproducing the parts which are cut off, a circumſtance that naturally brings to mind the fabulous ſtory of the Lernean hydra. Dr. Hill called them biota, on account of the ſtrong principle of life with which every part is endued.

Leeuwenhoeck, whoſe indefatigable induſtry in his reſearches after ſmall inſects permitted very few things to eſcape his notice,

diſcovered

diſcovered theſe animals, and gave ſome account of them in the Philoſophical Tranſactions for the year 1703. There is alſo in the ſame volume a letter from an anonymous hand on this ſubject. We had, however, no regular account of them, their various habits, their different ſpecies, or of their wonderful properties, till the year 1740, when they firſt engaged the attention of Mr. Trembley, to whoſe aſſiduity and obſervations we are indebted for the knowledge of their nature and œconomy.

Before theſe diſcoveries of Mr. Trembley, Leibnitz and Boerhaave, by reflections on the various gradations in the ſcale of animated nature, had endeavoured to prove that there might be degrees of life between the animal and the plant, and that animals might be found which would propagate by ſlips, like plants. Theſe conjectures were verified by Mr. Trembley, but not in conſequence of any preconceived ideas in favour of ſuch a ſuppoſition; on the contrary, it was only by repeated obſervations that he could deſtroy his own prejudices, and join theſe wonderful beings to the animal kingdom.

Though natural hiſtory is ſo fruitful in extraordinary facts, it has hitherto produced none ſo ſingular as the various properties of the different ſpecies of the hydra.

I ſhall endeavour, firſt, to trace the progreſs of this diſcovery, in which we ſhall ſee with what ſage caution and accuracy Mr. Trembley, and other naturaliſts, examined this wonderful phænomenon, and what accumulated evidence was judged neceſſary to eſtabliſh the facts.

We find Mr. Trembley writing in January, 1741, to Mr. Bonnet, that he did not know whether he ſhould call the object which then engaged his attention a plant or an animal. "I have ſtudied it, ſays he, ever ſince June laſt, and have found in it ſtriking characteriſtics of both plant and animal. It is a little aquatic being. At firſt ſight every one imagines it to be a plant; but if it be a plant, it is ſenſitive and ambulant; if it be an animal, it may be propagated by ſlips, or cuttings, like many plants." It was not till the month of March, in the ſame year, that he could ſatisfy himſelf as to their nature.

When Mr. Reaumur ſaw, for the firſt time, two polypes formed from one that he had divided into two parts, he could hardly believe his eyes; and even after having repeated the operation an hundred times, and again examined it an hundred more, he ſays, that the ſight was not become familiar to him.

The firſt account the Royal Society received of the ſurprizing properties of this inſect, was in a letter from M. Buffon (dated the 18th of July, 1741) to Martin Folkes, Eſq. their preſident, acquainting them with the diſcovery of a ſmall inſect called a polypus, which is found ſticking about the common duck-weed, and which, being cut in two, puts forth from the upper part a tail, and from the lower end a head, ſo as to become two animals inſtead of one. If it be cut into three parts, the middlemoſt puts out from one end a head, and from the other a tail, ſo as to become three diſtinct animals, all living like the firſt, and performing the various offices of their ſpecies: which obſervations are, adds M. Buffon, well averred.

There is no phænomenon in all natural hiſtory more aſtoniſhing than this, that man, at pleaſure, ſhould have a kind of creative power, and out of one life make two, each completely formed with all it's apparatus and functions, each with it's perceptions and powers of motion and ſelf-preſervation, each as complete in all reſpects as that from which it derived it's exiſtence, and equally enjoying the humble gratifications of it's nature.*

Mr. Folkes, in confirmation of the foregoing article, communicated to the ſociety a letter from C. Bentink, Eſq. at the Hague, dated September, deſcribing the inſects diſcovered by Mr. Trembley, adding, that he himſelf had ſeen them. In November a letter was read from Dr. Gronovius, of Leyden, giving an account of a water inſect, not yet known to or deſcribed by any author ; after eſcribing it, he adds, "but what is more ſurprizing, if this animal is cut into five or ſix pieces, in a few hours there will be as many animals, exactly ſimilar to their parent." The accounts of this animal were ſo extraordinary, that they were not credited until Profeſſors Albinus and Muſſchenbrock were provided with animals, and found all that had been related thereof to be exactly true.

November 25, a letter from Cambridge was read at the Royal Society, in which the author endeavours to leſſen, by reaſon, the prejudices which then combated the belief of theſe facts. "Some of our friends, ſays the author, who are firmly attached to the general metaphyſical notions they have formerly learned, reaſon ſtrongly

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Goldſmith's Hiſtory of the Earth and Animated Nature.

ſtrongly againſt the poſſibility of ſuch a fact; but I have myſelf owned, on other occaſions, my diſtruſt of the truth, or certainty at leaſt, of ſome of thoſe principles, and I ſhall make no ſcruple of acknowledging, that I have already ſeen ſo many ſtrange things in nature, that I am become very diffident of all general aſſertions, and very cautious in affirming what may or may not poſſibly be. The moſt common operations, both of the animal and vegetable world, are all in themſelves aſtoniſhing, and nothing but daily experience and conſtant obſervation can make us ſee, without amazement, an animal bring forth another of the ſame kind, or a tree bloſſom and bear leaves and fruit.

" The ſame obſervation and experience make it alſo familiar to us, that beſides the firſt way of propagating vegetables from their reſpective fruit and ſeed, they are alſo propagated from cuttings, and every one knows that a twig of a willow particularly, cut off and only ſtuck into the ground, does preſently take root and grow, and become as real and perfect a tree as the original one from which it was taken. Here then we find in the vegetable kingdom, quite common, the very thing of which we have an example before us in the animal kingdom, in this new-diſcovered inſect. The beſt philoſophers have long obſerved ſtrong analogies between theſe two claſſes of beings; and the more they have penetrated into nature, the more they have extended this analogy: now in ſuch a ſcale, who is the man that will be bold to ſay, juſt here animal life entirely ends, and here vegetable life begins? or, juſt ſo far, and no farther, one ſort of operation goes; and juſt here another ſort, quite different, takes it's place? or again, who will venture to ſay, life in every animal is a thing abſolutely different from that which we dignify by the ſame name in every vegetable?" Thus does the author endeavour to perſuade the prejudiced, and lead them to pay attention to the facts which were now laid open to their view, and which were further confirmed by a letter from Mr. Trembley, in January, 1740; which letter was ſtrengthened by an extract from the preface to the ſixth volume of Mr. de Reaumur's hiſtory of inſects. In March, 1742, Mr. Folkes gave an account of them to the Royal Society, from obſervations made on ſeveral polypes which had been ſent by Mr. Trembley from Holland to him. The inſects now began to be known, and were ſoon found in England, and the experiments that had been made on them abroad were publiſhed by M. Folkes,* my father,† and Mr. Baker: ‡ conviction now became too ſtrong for argument, and metaphyſical objections gave way to facts.

This animal is deſcribed in the following manner: §

### HYDRA.

Animal baſi ſe affigens, vagum, gelatinoſum, lineare nudum, contractile. Os terminale, cirrhis ſetaceis cinctum. Prolibus lateralibus (autumno ovis) deciduis.

This animal fixes itſelf by it's baſe, it is gelatinous, linear naked, can contract itſelf, and change it's place. It's mouth, which is at one end, is ſurrounded by hair, like feelers. It ſends forth it's young ones from it's ſides, which drop off; but in the autumn it produces eggs from it's ſide.

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* Philoſophical Tranſactions.

† Micrographia Illuſtrata.

‡ Natural Hiſtory of the Polype.

§ Elliſs's Nat. Hiſt. of Zoophytes, Lin. Syſt. Nat. p. 1320.

1. Hydra viridis, tentaculis ſubdenis brevioribus.

Green polype, generally with about ten ſhort arms; it is repreſented at Fig. 5, Plate XXI.

2. Hydra fuſca, tentaculis ſuboctonis longiſſimis.

This polype has very long arms, often eight in number; it is repreſented at Plate XXI. Fig. 7. The arms are ſeveral times longer than the body.

3. Hydra griſea, tentaculis ſubſeptenis longioribus.

This polype has alſo generally long arms, in number about ſeven; it is of a yellowiſh colour, ſmall towards the bottom; it is repreſented at Fig. 6, Plate XXI.

4. Hydra pallens, tentaculis ſubſenis mediocribus.

The arms of this polype are generally about ſix in number, and of a moderate length.

5. Hydra hydatula, tentaculis quaternis obſoletis corpore veſicario, Fig. 1, 2, 3, 4, Plate XXI.

This polype has a veſicular body, and four obſolete arms; is found in the abdomen of ſheep, ſwine, &c.

6. Hydra ſtentorea, tentaculis ciliaribus corpore infundibuliformi.

This polype has been called tunnel ſhaped; the mouth is ſurrounded with a row of hairs; it is repreſented at Fig. 27 and 28, Plate XXII.

7. Hydra ſocialis mutica toroſa rugoſa.

Bearded thick and wrinkled, Fig. 11, Plate XXI.

## OF THE HYDRA VIRIDIS, HYDRA FUSCA, AND HYDRA GRISEA.

Theſe three ſpecies of the hydra having been thoſe on which the greateſt number of experiments have been made, and of which we have the beſt information, it is of theſe only we ſhall ſpeak in the following account, unleſs we give particular notice thereof to the reader.

There are few animals more difficult to deſcribe than the hydra, as it has ſcarce any thing conſtant in it's form, varying continually in it's figure; they are often ſo beſet with young, as to appear ramoſe and divaricated, the young ones conſtituting as it were a part of the parent's body.

Whoever has looked with care at the bottom of a wet ſhallow ditch, when the water is ſtagnant, and the ſun has been powerful, may remember to have ſeen many little tranſparent lumps, of a jelly-like appearance, about the ſize of a pea, and flatted on one ſide; the ſame appearances are alſo often to be ſeen on the under ſide of the leaves of thoſe weeds, or plants, that grow on the ſurface of the water; theſe are the hydra, gathered up into a quieſcent ſtate, and ſeemingly inanimate, becauſe either undiſturbed, or not excited by the calls of appetite to action. They are generally fixed by one end to ſome ſolid ſubſtance, at the other end there is a large opening, round about which the arms are placed as ſo many rays round a center, which center is the mouth.

They are ſlender and pellucid, formed of a kind of tender ſubſtance, in conſiſtence ſomething like the horns of a ſnail, and can contract the body into a very ſmall compaſs, or extend it to a conſiderable length. They can do the ſame with the arms; with theſe they ſeize minute worms and various kinds of aquatic inſects, bring them to the mouth and ſwallow them. After the food is digeſted, and the nutritive parts which are employed in ſuſtaining it's life are ſeparated from the reſt, they reject the remainder by the mouth.

The firſt polype which Mr. Trembley diſcovered was one of the hydra viridis, repreſented at Fig. 5, Plate XXI. Theſe are generally of a fine green colour. The indications of ſpontaneous motion were firſt perceived in the arms of theſe little creatures; they can extend or contract, bend and wind them divers ways. Upon the ſlighteſt touch they contract themſelves ſo much, as to appear little more than a grain, of a green ſubſtance, the arms diſappearing entirely. He ſoon after found the hydra griſea, Fig. 6, and ſaw it eat, ſwallow, and digeſt worms much larger than itſelf. This diſcovery was ſoon followed by that of the hydra fuſca, Fig. 7, Plate XXI.

The moſt general attitudes of theſe hydræ are thoſe which are repreſented in Fig. 5 and 6, Plate XXI. They fix the poſterior extremity *b* againſt a plant, or other ſubſtance, as *e f*; the body *a b*, and the arms *a c*, being extended in the water. There is a ſmall difference in the attitudes of the three kinds which we are now deſcribing.

The bodies of the hydra viridis, Fig. 5, and of the hydra griſea, Fig. 6, diminiſh from the anterior to the poſterior extremity by an almoſt inſenſible gradation. The hydra fuſca does not diminiſh in the ſame gradual manner, but from the anterior extremity *a* to the part *d*, which is often two-thirds of the length of their body, it is nearly of an equal ſize; from this part it becomes abruptly ſmaller, and goes on from thence of a regular ſize to the end. The number of arms in theſe three kinds are at leaſt ſix, and at moſt twelve or thirteen, though eighteen may ſometimes be found on the hydra griſea. They can contract their bodies till they are not above one-tenth of an inch in length; they can alſo ſtop at any intermediate degree, either of contraction or extenſion, from the greateſt to the leaſt. The ſpecies repreſented at Fig. 5 are generallly about half an inch long when ſtretched out. Thoſe exhibited at Fig. 6 and 7 are about three-fourths of an inch, or one inch, in length, though ſome are to be found at times about an inch and an half long. The arms of the hydra viridis, Fig. 5, are ſeldom longer than their bodies;

thoſe of Fig. 6 are commonly one inch long, while thoſe of Fig. 7 are generally about eight inches; whence Mr. Trembley has called it the long-armed polype.

The bulk of the hydræ decreaſes in proportion as they extend themſelves, and vice verſa. They may be made to contract themſelves, either by touching them, or agitating the water in which they are contained. They all contract themſelves ſo much when taken out of the water, as to appear only like a little lump of jelly. They can contract or extend their arms without extending or contracting the body, or the body without making any alteration in the arms: or they can contract or dilate only ſome of the arms, independent of the reſt: they can alſo bend their body and arms in all poſſible directions. Thoſe repreſented at Fig. 7, let their arms in general hang down, making different turns and returns, often directing ſome of them back again to the top of the water. They can alſo dilate the body at different places, ſometimes at one part, and then again at another; ſometimes they are thick ſet with folds, which, if careleſsly viewed, might be taken for rings.

They have a progreſſive motion, which is performed by that power by which they ſtretch out, contract, and turn themſelves every way. For ſuppoſe the hydra, or polype, *a b*, Fig. 16, Plate XXI. to be fixed by the tail *b*, having the body and arms *a* extended in the water, in order to advance, it draws itſelf together, by bending itſelf ſo as to bring the head and arms down to the ſubſtance on which it is to move; to do this, it fixes the head, or the arms, as in Fig. 17; when theſe are well fixed, it looſens the tail, and draws it towards the head, as in Fig. 18, which it again looſens, and reſting on the tail, ſtretches it out, as in Fig. 19. It is eaſy to ſee from this account, that their manner of walking is very analogous to that of various terreſtrial and aquatic animals. They walk very ſlow, often ſtopping in the middle of a ſtep, turning and winding their body and arms every way. Their ſtep is ſometimes very ſingular, as in the following inſtance: ſuppoſe the polype *a b*, Fig. 20, to be fixed by the tail *b*, the body and arms being extended in the water, it firſt bends the fore-part towards the ſubſtance on which it is moving, and fixes it thereto as at *a*, Fig. 21; it then looſens the lower end, and raiſes it up perpendicular, as in Fig. 22; now bending the body to the other ſide, it fixes the tail as in Fig. 23; then looſening the anterior end, it riſes up, as in Fig. 24.

They deſcend at pleaſure to the bottom of the water, and aſcend again, either by the ſides, or upon ſome aquatic plants; they often hang from the ſurface of the water, reſting as it were upon the tail; at other times they are ſuſpended by one arm from it. They walk alſo with eaſe upon the ſurface of the water. If the extremity of the tail *b*, Fig. 7, be examined with a magnifying glaſs, a ſmall part of it will be found to be dry, and above the ſurface of the water, and as it were in a little concave ſpace, of which the tail forms the bottom, ſo that it ſeems to be ſuſpended on the ſurface of the water, on the ſame principle that a ſmall pin, or needle, is made to ſwim.

Hence when a polype means to paſs from the ſides of the glaſs to the ſurface of the water, it has only to put that part out of the water by which it means to be ſupported, and give it time to dry, which it always does upon theſe occaſions. They attach themſelves ſo firmly by the tail to aquatic plants, ſtones, &c. as not to be eaſily driven from the place where they have fixed themſelves; they often further ſtrengthen theſe attachments, by means of one or two of their arms, which they throw out and fix to adjacent ſubſtances as ſo many anchors.

The mouth of the polype, or hydra, is ſituated at the fore-part of the body, in the middle between the ſhooting forth of the arms. The mouth aſſumes different appearances, according to the different purpoſes of the inſect; ſometimes it is lengthened out, and forms a little conical nipple, as at Fig. 13, Plate XXIII. A; ſometimes it appears truncated, as at Fig. 8, Plate XXI; at other times the interval between the arms appears cloſed, as at Fig. 2 and 12, Plate XXIII. A; or hollow, as at Fig. 11, Plate XXIII. A. If it is obſerved with a deep magnifier, in either of the two laſt caſes, a ſmall aperture may be diſcovered.

The mouth of the polype opens into the ſtomach, which is a kind of bag, or gut, that goes from head to tail; this may be perceived by the naked eye, when they are expoſed to a ſtrong light, or a candle placed on the oppoſite ſide to the eye; for the colour of the polype does not deſtroy the tranſparency thereof. The ſtomach will, however, be better ſeen, if the eye be aſſiſted by a deep magnifier; one of them is repreſented as highly magnified, at Fig. 8, Plate XXI. To be fully ſatisfied whether they were perforated throughout, Mr. Trembley cut one tranſverſely into three parts; each piece immediately contracted itſelf, and became very ſhort, and being placed in a ſhallow glaſs full of water, and viewed through the microſcope, they were found to be viſibly perforated. They are repreſented as they appear in the microſcope, at Fig. 6, 7, 8, Plate XXIII. A; it's mouth was at the anterior end *a*, Fig. 8, of one of theſe parts. The tail was at the end *b* of the third part, Fig. 6; as this piece was alſo perforated, it plainly appears, that the tail of the hydra is open. The perforation, which is thus continued from one end to the other, is called the ſtomach, becauſe it contains and digeſts the aliments. The ſkin which incloſes the bag, and forms the ſtomach, is the ſkin of the polype itſelf; ſo that the animal may be ſaid to conſiſt of but one ſkin, diſpoſed in the form of a tube, or gut, open at both ends. On opening the polype, no veſſels are to be diſtinguiſhed; and whatever be the nature of it's organization, it muſt reſide in the ſkin.

The ſkin muſt be ſo far organized, as to perform all the operations neceſſary for the nutrition and growth of the animal, without conſidering thoſe that are neceſſary for it's various motions. Whatever are the means the Author of nature has employed for theſe purpoſes, we are ignorant of them. If their ſkin is examined by a microſcope, it appears like ſhagreen, or as if it were covered with little grains; theſe are more or leſs ſeparated from each other, according to the degree in which the body is extended or contracted.

If the lips of a polype be cut tranſverſely, and placed ſo that the cut part of the ſkin may lie directly before the microſcope, the ſkin throughout it's whole thickneſs will be found to conſiſt of an infinite number of theſe grains. To know whether the inſide of the ſtomach was formed of ſimilar grains, ſeveral of them have been laid open and examined by the microſcope; the interior ſurface was then found to conſiſt of an immenſe number of them, being as it were more ſhagreened than the exterior one, and leſs tranſparent. The grains are not ſtrongly united to each other, but may be ſeparated without much trouble. Fig. 10, Plate XXIII. A, repreſents a piece of ſkin thus laid open. To examine theſe particulars further, a piece of ſkin a, Fig. 9, was laid in a few drops of water, on a piece of glaſs, before the microſcope, and ſome of the grains were ſeparated from it, as at b c d, by preſſing them with the point of a pin; in endeavouring to open them, they ſpread themſelves into all parts of the water, and at laſt remained in heaps, as at e and f.

If a polype is carefully placed before the microſcope, without wounding it, you will ſeldom be diſappointed in ſeeing ſome of theſe grains detach themſelves from the ſuperficies thereof, and that even in the moſt healthy.

But if the grains ſeparate themſelves in large quantities, it is the ſymptom of a very dangerous diſorder; the ſurface of the polype thus attached becomes more and more irregular, and is no longer well terminated and defined as before. The grains fall off on all ſides, the body and arms contract and dilate, it becomes of a white ſhining colour, loſes it's form as at a, Fig. 4, Plate XXIII. A, and then diſſolving into a heap of grains, as at b, Fig. 5. The progreſs of this diſorder is moſt eaſily obſerved in the hydra viridis.

A very attentive and accurate examination ſhews that the ſkin is formed of a kind of glarous ſubſtance, a ſpecies of gum, which fills up the intervals between the grains, in which they are lodged, and by which they are attached (though weakly) together.

It has been already obſerved, that it is to theſe grains that it owes it's ſhagreen-like appearance; it is from them alſo that it derives it's colour; for when they are ſeparated from the polype, they are the ſame colour with it; whereas the glarous matter is without any diſtinguiſhing colour. The conſtruction of the polype ſeems then to be confined to theſe glandular grains, to the viſcous matter, and the inviſible fibres which act upon the glarous ſubſtance.

The ſtructure of the arms of the polypes are very analogous to that of their body. When they are examined by the microſcope, either in a contracted or dilated ſtate, their ſurface is ſhagreened; if the arm be much contracted, it appears more ſo than the body; on the contrary, it appears leſs ſo in proportion as they are more extended, almoſt quite ſmooth when at their full extenſion; ſo that in the hydra viridis the appearance of the arms is continually varying, and theſe variations are more ſenſible towards the extremity of the arm than at it's origin, as at Fig. 10, Plate XXI. but more thinly ſcattered, or farther aſunder, in the parts further on, as at Fig. 9, Plate XXI. The extremity is often terminated by a knob, the hairs which are exhibited in Fig. 9, cannot be ſeen without a very deep magnifier, however they indicate a further degree of organization in this little animal.

All animals of this kind have a remarkable attachment to turn towards the light, and this might naturally induce the inquirer to look for their eyes; but how carefully ſoever this ſearch has been purſued, and however excellent the microſcope with which every part has been examined, yet no appearance of this organ was found. Notwithſtanding this, they conſtantly turn themſelves towards the light; ſo that if that part of the glaſs in which we placed them be turned from it, they will be found the next day to have removed themſelves to the ſide that is next the light, and the dark ſide will be quite depopulated.

## OF THE FOOD OF THE HYDRÆ, AND THEIR METHOD OF SEIZING AND SWALLOWING THEIR PREY.

As the hydra fuſca, Fig. 7, Pl. XXI. has the longeſt arms, it's manner of feeding, and the different manœuvres it makes uſe of to ſeize and manage it's prey, are more remarkable than thoſe of the two other ſpecies; it will be, therefore, this kind only which will be principally ſpoken of under the preſent head. To view them properly, they ſhould be placed in a glaſs ſeven or eight inches deep. If the polype is fixed near the top of the glaſs, their arms for the moſt part hang down towards the bottom. This is a very convenient ſituation for giving them their food, and to obſerve how they manage it.

An hungry polype ſpreads it's arms as a fiſherman his nets; it extends them every way, ſo that they form a circle of conſiderable extent, every part of which is entirely within the reach of one of them; in this expanded poſture it lies in expectation of it's food; whatever comes within the verge of this circle is ſeized by one or another of it's arms. The arms are then contracted till the prey is brought to the mouth, when it is ſoon devoured. While the arms are contracting, and exerted vigorouſly, (to counteract the efforts the animal which it has ſeized makes in order to eſcape) they may be obſerved to ſwell like the muſcles of the human body when they are in a ſtate of exertion.

The polype does not always wait for it's prey, it feels for it, and in a manner follows it. It may be aſked, how can it do this when it has no eyes? or, do the glandular grains anſwer this purpoſe? Who can anſwer the queſtion? what are our own eyes but glandular grains of a larger ſize? If this ſhould be the caſe, our hydra would again exceed and realize the fables of the ancients, being an argus entirely compoſed of eyes. Be this as it may, they are certainly in poſſeſſion of ſome ſentiment by which they can perceive the approach of their prey, and which renders them attentive to all that may confirm or deſtroy this perception.

When the arms of a polype are extended, put a millepedes, or any kind of worm, into a glaſs, (ſee Fig. 1, Pl. XXIV. A) and with the point of a pencil puſh it towards one of the arms; as ſoon as it touches this it is ſeized; the worm, or millepedes, endeavours by quick and ſtrong efforts to diſengage itſelf, often ſwimming and dragging the arm from one ſide of the glaſs to the other. This violent motion of the prey obliges the polype to contract ſtrongly the arm, in doing which it often twiſts it in the form of a corkſcrew, as at o i, by which means it ſhortens it more rapidly; the ſtruggles of the devoted animal ſoon bring it in contact with another arm, theſe contracting further, the little creature is preſently engaged with all the arms, which contract ſo much as to convey it to the mouth, againſt which it is held and ſubdued.

When a polype has nothing to eat, it's mouth is generally open, but ſo ſmall that it can ſcarce be perceived without the aſſiſtance of a magnifying glaſs; but as ſoon as the arms have conveyed the prey to the mouth, it opens itſelf wider, and this in proportion to the ſize of the animal that is to be devoured; the lips gradually dilate, and adjuſt themſelves accurately to the figure of the prey. The greateſt part of the animals on which the polype feeds, are to it's mouth what an apple, the ſize of our heads, would be to the mouth of a man.

The worms, &c. which are ſeized by the polype are not always brought to the mouth in the ſame ſituation; if they are preſented to it by one of their extremities, it is not requiſite that the polype ſhould open it's mouth conſiderably, and in effect it only opens it ſo wide, as preciſely to give entrance to the worm, Fig. 5, Plate XXIV. A. If it be not too long for the ſtomach, it remains there extended; but if it be longer, the end which firſt enters is bent, ſo that when the worm is entirely ſwallowed, it may be ſeen lying folded in the ſtomach, Fig. 12, Plate XXIV. B.

If the middle, or any other part of the worm, be preſented to the mouth of the polype, it ſeizes this part with the lips, extending them on both ſides, and applying them againſt the worm, ſo that the mouth aſſumes the form of a boat, pointed at each end, Fig. 2, Plate XXIV. A; the polype gradually cloſes the two points of it's boat-like lips, and by this motion and ſuction ſwallows the worm, Fig. 4, Plate XXIV. A.

A worm is killed ſo ſoon by a polype, that Mr. Fontana thinks they muſt contain the moſt active and powerful venom; for it's lips ſcarce touch the worm but it expires, ſo great is the energy of the poiſon it conveys into it, though no wound can be obſerved in the dead animal.

As ſoon as the ſtomach is filled, it's capacity is enlarged, the body is ſhortened, Fig. 6, Plate XXIV. A, the arms are for the moſt part contracted, the polype hangs down without motion, and appears to be in a kind of ſtupor, and very different from it's extended ſhape; but in proportion as the food is digeſted, and it has voided the excrementitious parts, the body lengthens, and gradually recovers it's form.

The tranſparency of the polype permits us to ſee diſtinctly the worm which has been ſwallowed, Fig. 12, Plate XXIV. B, which gradually loſes it's form. It is at firſt macerated in the ſtomach of the polype, and when the nutritious juices are ſeparated from it, the remainder is diſcharged by the mouth, Fig. 13. It is with theſe as with other voracious animals, as they eat a great deal at once, ſo alſo they can faſt for a long time. The hiſtory of inſects furniſhes many examples of this kind.

One circumſtance is obſervable, which probably contributes much to the digeſtion of their food, namely, that the aliments are continually puſhed back from one extremity to the other of the ſtomach; this motion may be eaſily obſerved with a microſcope, in a polype which is not too full, and in which the food has been already divided into little fragments. For theſe obſervations, it is beſt to feed the polype with ſuch food as will give a lively-coloured juice; as for example, thoſe worms whoſe inteſtines are filled with red ſubſtances: for by this means we ſhall ſee that the nutritious juices are conveyed not only to the extremity of the body, but alſo into the arms, from whence it is probable that each of the arms form alſo a kind of gut, which communicates with that of the body. Some bits of a ſmall black ſnail, that is frequently to be found in our ditches, was given to a polype. The ſubſtance of this ſkin was ſoon reduced into a pulp, conſiſting of little black fragments; on examining the polype with the microſcope, theſe particles were perceived to be driven about the ſtomach, and to paſs from head to tail, and into their arms, even where theſe were as fine as a thread; they were afterwards forced into the ſtomach, and from thence to the tail, from whence they were again driven into the arms, and ſo on.

The grains take their tinge from the food which nouriſhes the polypes; theſe grains become red or black, if the polype be fed with juices that are either red or black; and they are more or leſs tinged with theſe different colours, in proportion to the ſtrength and quantity of the nutritive juices. It is alſo obſervable, that they loſe their colour if fed with aliments that are not of the ſame colour with themſelves.

The polypes feed on the greater part of thoſe inſects that are to be found in freſh water. They may be nouriſhed with worms, the larva of gnats, &c. they will alſo eat larger animals if they are cut into ſmall pieces, as ſnails, large aquatic inſects, ſmall fiſh, butchers meat, &c. Sometimes two polypes ſeize the ſame worm, and each begins to ſwallow it's own end, continuing ſo to do till their mouths meet, Fig. 8, Plate XXIV. A; in this poſition they remain for ſome time, at laſt the worm breaks, and each has it's ſhare; ſometimes the combat does not end here, for each continuing to diſpute the prize, one of the polypes opens it's mouth advantageouſly, and ſwallows the other with it's portion of the worm, ſee Fig. 14, Plate XXIV. A; this combat ends more fortunately for the devoured polype than might be at firſt expected,

pected, for the other often gets the prey out of it's ſtomach, but lets it out again ſound and ſafe, after having impriſoned it above an hour. From hence we learn, that the ſtomach of the polype, which ſo ſoon diſſolves the animal ſubſtances which are conveyed into it, is not capable of digeſting that of another polype.

Fig. 5, Plate XXIV. A, repreſents a polype with one-half of a millipedes in it's mouth, as at a; the other part without as at m. Fig. 1, Plate XXIV. A, repreſents one ſuſpended in water by a piece of packthread; c n, a millipedes ſeized by it, and drawn partly towards the mouth; i o the bendings in the arm; p an arm in ſearch of a ſmall aquatic inſect. Fig. 2, Plate XXIV. A, a polype ſtretching itſelf into a boat-like form, to take or ſwallow a worm lying ſideways. Fig. 4, Plate XXIV. A, the ſame polype with the worm ſwallowed and bent within it. Fig. 6, the ſame plate is a polype in the ſituation they generally aſſume when they have ſatisfied their voracious appetite. Fig. 7, one that has ſwallowed a ſmall monoculus. a, Fig. 9, one whoſe arms are loaded with monoculi. Fig. 10, a polype full of them from head to tail. Fig. 3, one that has only ſwallowed a few of them.

In this paragraph I ſhall ſpeak of ſome of the figures contained in Plate XXIV. B. Fig. 12, a worm ſeen within the ſkin of a polype. Fig. 13, diſgorging the excrementitious parts thereof. Fig. 11 repreſents one engaged with a very large worm.

Fig. 8, Plate XXIV. A, repreſents two polypes engaged in combat for a worm, of which both of them have ſwallowed a part.

Fig. 12, Plate XXI. a polype that has ſwallowed a ſmall fiſh, and taken the ſhape thereof.

## OF THE GENERATION OF THE HYDRÆ.

As the hydra fuſca and the hydra griſea are conſiderably larger than the hydra viridis, it is more eaſy to obſerve the manner of their producing their young. It is upon theſe, therefore, that moſt of the obſervations here recited have been made. If one of them be examined in ſummer, when the animals are moſt active and more particularly prepared for propagation, it will be found to burgeon forth from it's ſides ſeveral little tubercles, or knobs, which grow larger and larger every day; after two or three days inſpection, what at firſt appeared but a ſmall excreſcence, takes the figure of a ſmall animal, entirely reſembling it's parent.

When a young polype firſt begins to ſhoot, the excreſcence terminates in a point as at e, Fig. 24, Plate XXIV. B, ſo that it is rather of a conical figure, and of a deeper colour than that of the body. This cone ſoon becomes truncated, and in a little time appears cylindrical. The arms then begin to ſhoot from the anterior end c i, Fig. 24, Plate XXIV. B. The tail adheres to the body of the parent, but grows gradually ſmaller, till at laſt it only adheres by a point b, Fig, 23, Plate XXIV. B; it is then ready to be ſeparated; for this purpoſe the mother and young ones fix themſelves to the glaſs, or other ſubſtance upon which they may be ſituated. They have then only to give a ſudden jerk, and they are divided from each other. There are ſome trifling differences to be obſerved now and then in their performing this operation, which it would be too tedious to enumerate here,

here. A polype, a b, Fig. 20, with a young one, c d, places it's body in an arch of a circle a d b, againſt the ſides of the glaſs, the young one being fixed at the top d of the arch, with it's head alſo fixed againſt the glaſs; ſo that the mother, by contracting the body, and thus becoming ſtrait, looſens herſelf from the young one.

The young ones ſhoot in proportion to the warmth of the weather, and the nature of the food eaten by the mother; ſome have been obſerved to be perfectly formed in twenty-four hours, while others have required fifteen days for the ſame purpoſe; the firſt were produced in the midſt of ſummer, the latter in a cold ſeaſon.

The tail of the young polype communicates with and partakes of the food from the parent in the ſame manner as it's own arms do, and the food lies in the ſame manner as in the arms. When this fœtus is furniſhed with arms, it catches it's prey, ſwallows, digeſts, and diſtributes the juices thereof, even to the parent body; every good is common to each. Here then we have evident communication between the fœtus and the mother; this communication was further proved by the following experiment. A large polype (one of the hydra fuſca) was placed on a ſlip of paper, in a little water; the middle of the body of the young one was cut, and the ſuperior part of that end which remained fixed to the parent was found to be open. The parent polype was then cut on each ſide of the ſhoot. Thus a ſhort cylinder was obtained, which was open at both ends. This being viewed through a microſcope, the light was ſeen to come through the ſide ſlip, or young one, into the ſtomach of the old one. For further conviction, the cylindrical portion was cut lengthways; on obſerving theſe parts, not only the hole t of communication, Fig. 17, Plate XXIV. B, was diſtinctly ſeen, but one might ſee through the end o of the young one. On changing the ſituation of theſe two pieces of prepared polypi, and looking through the opening e, Fig. 18, the daylight was ſeen through the hole of communication i.

This communication between the parent polype and it's young ones may be ſeen on feeding them; for after the parent, a b, Fig. 22, Plate XXIV. B, has eaten, the body of the young ones ſwell, being filled with the aliments as if they themſelves had been eating. In the hydra fuſca the young ones do not proceed from the tail part b c, Fig. 16, Plate XXIII. B, but only from the part a c, with this exception, there is no particular part of the body before the reſt, on which they produce their young. Some of them have been ſo cloſely obſerved, and have ſo greatly multiplied, that there would be ſcarce any impropriety in ſaying they produced their young ones from all the exterior parts of the body. A polype puts forth often five or ſix young ones at the ſame time. Mr. Trembley has had ſome that have produced nine or ten at the ſame time, and when one dropped off another came in it's place.

Though Mr. Trembley had for two years thouſands of them under his eye, and conſidered them with the moſt ſcrupulous attention, he never obſerved any thing like copulation. To be more certain on this head, he took two young ones the inſtant they came from their parent, and placed them in ſeparate glaſſes; they both multiplied, not only themſelves, but their offspring, which were ſeparated and watched in the ſame manner to the ſeventh generation; nay, they have even the faculty of multiplying while they adhere to the parent. The arms of the young ones do not ſprout till the body has attained ſome length.

Several excreſcencies, or buds, often appear at the ſame time on a polype, which are ſo many polypes growing from one trunk; whilſt theſe are developing, they alſo bud, which buds again put forth little ones, the parent and the young ones forming a ſingular kind of animal ſociety, in which all participate of the ſame life, and the ſame wants. In this ſtate the parent appears like a ſhrub thick ſet with branches. Several generations are often thus attached to one another, and all to the parent polype; after a time, this tree of polypes, or hydræ, is decompoſed, and gives birth to new generations, or freſh genealogical trees. Here we ſee a ſurprizing chain of exiſtence continued, and numbers of animals naturally produced, without any union of ſexes.

From Fig. 16, Plate XXIII. B, the reader may form an idea of the promptitude with which theſe creatures increaſe and multiply; the whole group formed by the parent and it's young was about an inch and an half long, and one inch broad, the arms of the mother and her nineteen little ones hanging down towards the bottom of the veſſel; the animal would eat about twelve monoculi per day, and the little ones about twenty among them, or rather more than thirty for the groupe.

### OF THE RE-PRODUCTION OF POLYPES.

A polype cut tranſverſely, or longitudinally, in two or three parts, is not deſtroyed, each part in a little time becomes a perfect polype. This ſpecies of fecundity is ſo great in theſe animals, that even a ſmall portion of their ſkin will become a little polype, a new animal riſing as it were from the ruins of the old, each ſmall fragment yielding a polype. If the young ones are mutilated while they grow upon the parent, the mutilated parts are re-produced; the ſame changes ſucceed alſo in the parent. A truncated portion will put forth young before it is perfectly formed itſelf, or has acquired it's new head and taïl; ſometimes the head of the young one ſupplies the place of that which would grow out of the anterior part of the trunk.

If a polype is ſlit, beginning at the head, and proceeding to the middle of the body, a polype will be formed with two heads, and will eat at the ſame time with both. If the polype is ſlit into ſix or ſeven parts, it becomes a hydra, with ſix or ſeven heads. If theſe are again divided, we ſhall have one with fourteen; cut off theſe, and as many new ones will ſpring up in their place, and the heads thus cut off will become new polypes, of which ſo many new hydras may again be formed: ſo that in every reſpect it exceeds the fabulous relation of the Lernean hydra.

As if the wonders already related of the polype were not ſufficient to engage our attention to theſe ſingular animals, new circumſtances, as ſurprizing as the foregoing, preſent themſelves to convince us of the imperfection of our ideas of animality, and of the greatneſs of the power of our Lord and Saviour, who is the ſource and origin of every degree of life, in all it's immenſe gradations, as unity is the origin of number, in all it's varied ſeries, multiplied proportions and combinations; now as numbers may be conſidered as being recipient of unity, in order to make manifeſt the wonderful powers thereof, ſo the univerſe and it's parts are adapted to receive life from the ſource of all life, and thus become repreſentatives of his immenſity and eternity.

The polypes may be as it were grafted together. If the truncated portions of a polype are placed end to end, and then puſhed together with a gentle force, they will unite, and form a ſingle one. The union is at firſt made by a fine thread, and the portions are diſtinguiſhed by a narrow neck, which gradually fills up and diſappears, the food paſſing from one portion to another. Portions, not only of the ſame, but pieces of different polypes, may be thus united together. You may fix the head of one polype to the trunk of another. And that which is thus produced will grow, eat, and multiply like another.

There is ſtill another method of uniting theſe animals together, more wonderful in it's nature, and leſs analogous to any known principles of animation, and more difficult to perform. It is effected by introducing one within the other, forcing the body of one into the mouth of the other, and puſhing it down ſo that their heads may be brought together; in this ſtate it muſt be kept for ſome time; the two individuals are at laſt united, and grafted into each other; and the polype, which was at firſt double, is converted into one, with a large quantity of arms, and performs all it's functions, like another.

The hydra fuſca furniſhes us with another prodigy, to which we know nothing that is ſimilar, either in the animal or vegetable kingdom. They may be turned inſide out like a glove, and notwithſtanding the apparent improbability of the circumſtance, they live and act as before. The lining, or coating, of the ſtomach now forms the epidermis, and the former epidermis now conſtitutes the coating of the ſtomach. A polype thus turned may often have young ones attached to it's ſide. If this is the caſe, after the operation they are of courſe incloſed in the ſtomach. Thoſe which have acquired a certain ſize extend themſelves towards the mouth, that they may get out when ſeparated from the body; thoſe which are but little grown turn themſelves inſide out, and by this means place themſelves again on the outſide of the parent polype.

The polype thus turned, combines itſelf a thouſand different ways. The fore-part often cloſes itſelf, and becomes a ſupernumerary tail. The polype which was at firſt ſtrait, now bends itſelf, ſo that the two tails reſemble the legs of a pair of compaſſes, which it can open and ſhut. The old mouth is at the joint as it were of the compaſſes; it cannot, however, act as one, ſo that a new one is formed near it, and in a little time you have a new ſpecies of hydra with ſeveral mouths.

Fig. 18, Plate XXIII. B, repreſents the upper part of a polype that has been divided into two parts, a the upper, c the lower part, the end c being ſomething larger than that of a common polype, and is ſenſibly perforated; in the ſummer time this part often walks and eats the ſame day it is cut.

Fig. 17, the other part of the ſame polype; the anterior end is very open, and the edges of it turned a little outwards, which afterwards folding inwards, cloſe the aperture. This end now appears ſwelled, as at c, Fig. 21; the arms ſhoot out from this end; at firſt three or four points only begin to ſhoot, as at c, Fig. 20, and while theſe increaſe in ſize, others appear between them; they can ſeize their prey, and eat before their arms have done growing. In the height of ſummer, the arms will often begin to ſhoot in twenty-four hours; but in cold weather it will be fifteen or twenty days before the head is formed.

Fig. 22 repreſents a polype that was cut cloſe under the arms; this became alſo a complete animal in a little time.

The ſides of a polype, that has been cut longitudinally, roll themſelves up in different ways, generally beginning at one of the extremities, rolling itſelf up in a heap, as at Fig. 19, Plate XXIII. B, with the outſide of the ſkin inwards; it ſoon unrolls itſelf, and the cut ſides form themſelves into a tube, whereof the edges a b and e i, Fig. 15, on both ſides, meet each other and unite. Sometimes they begin to join at the tail end, at other times the whole ſides gradually approach each other. The ſides join ſo cloſe, that from the firſt moment of their junction no ſcar can be diſcovered.

Fig. 14, Plate XXIII. B, repreſents a polype partly joined, as at i b, the part c a e not yet cloſed.

Fig. 29, Plate XXIII. B, repreſents a polype, the heads of which have been repeatedly divided, by which means it becomes literally a hydra.

Fig. 24 repreſents a polype that had been turned, endeavouring to turn itſelf back again, the ſkin of the anterior part lying back upon the other; the arms varying in their direction, being ſometimes turned towards the head, ſee Fig. 24 and 26, Plate XXIII. B, at others towards the tail. The anterior extremity c, formed by the edges of the reverſed part a, remained open for ſome days, and then began to cloſe, new arms ſhot out near the old ones, and ſeveral mouths were formed at thoſe parts where the arms joined the body.

Fig. 23, 25, 27, 28, repreſent the different changes that took place in another polype that had been turned inſide out, and the different revolutions it went through before it acquired a fixed ſtate. a c always ſhews the part the polype had turned back, and a b the part it could not turn back.

A polype, which has been partly turned back, remains but a little time in that ſituation. a, Fig. 28, Plate XXIII. B, the part where the portion it had turned back joined to the body a b; this became ſtrait, and formed a right angle with a b; the ſame day another head appeared at e, and ſeveral arms, a o a n, began to ſhoot from the mouth a; at the other ſide of this mouth there were the old arms a d. The next day the portion a c was drawn near the body, and formed an acute angle with it, as at Fig. 25. Fig. 27 repreſents the ſame ſwelled, after having ſwallowed a worm. Four days afterwards it's form had varied conſiderably, as may be ſeen by comparing Fig. 25 and 28, having now one common mouth and two ſmall polypes growing on it.

We may now be permitted to make a ſew reflections on this ſingular animal. On conſidering the various properties that have been already deſcribed, we ſhall find in them many particulars that are very analogous to others that are continually carrying on around us; we perceive that there is a ſucceſſive unfolding of new parts. In every organized frame there is a continual effort to extend it's ſphere of action, and enlarge the operation of that portion of life which is communicated to it. This gradual evolution requires a ſecret and curious mechaniſm to regulate and modify by re-action the continued conatus of the forming principle within it. The polype is an organized whole, of which each part, each molecule, each atom, tends to produce another; it is, if we may ſo ſpeak, one entire ovary, a compound of germ, or ſeed. In cutting a polype to pieces, the nouriſhing juices, which would have been employed in ſupporting the whole, are made to act upon each portion.

When a polype is divided longitudinally, it forms two half tubes; the oppoſite edges of theſe approach, and in a very ſhort time form a perfect tube. The ſides are made to touch each other by certain motions and contractions of the piece; but as ſoon as the edges come in contact, a ſlight adheſion takes place, the correſponding veſſels unite, and new ones are unfolded, as in a vegetable graft; by this means, the points of connection and coheſion are multiplied, the motion of the fluids are re-eſtabliſhed, and with them the vital œconomy. This is performed with more rapidity than in vegetables, becauſe the polype is nearly gelatinous, and it's parts are extremely ductile; this ductility is ſupported and preſerved by the element which it inhabits. The ſame reaſoning applies equally to explain the formation of ſo many heads to a polype, as conſtitute it a real hydra.

A new polype is formed out of ſmall portions, or fragments, in a very different manner, the operations in nature being always varied, according as the circumſtances differ; each fragment is puffed up, the ſkin ſeparated, and an empty ſpace is formed within it; this part is to become the ſtomach of the riſing polype, which ſoon ſends forth arms, and is formed to the perfection proper to it's kind. We learn from this inſtance, that the ſkin of the polype is not ſo ſimple as was at firſt imagined; for we find it dividing itſelf into two membranes, and forming thereby a cavity fit to perform all the functions of a ſtomach; but why theſe membranes are ſeparated in the ſmall portions, and not in the larger, we cannot tell; but though we are ignorant of this, and many more circumſtances relative to the re-production of theſe little animals, yet the foregoing facts enable us to underſtand better the nature of the exiſtence of thoſe polypes which have been turned inſide out.

For as that part which formed the interior ſkin of the ſtomach, in the little fragments before-mentioned, became the exterior part of the animal, the inſide of the polype is conſequently ſo ſimilar to the exterior ſkin, that one may be ſubſtituted for the other, without injuring the vital functions; from hence we might, in ſome meaſure, have inferred the poſſibility of the polypes living after it has been turned inſide out, independent of the fact itſelf.

The viſcera of the animal are ſituated in the thickneſs of the ſkin, and abſorbing pores are placed both on the inſide and outſide, ſo that the animal can live whether the ſkin is turned one way or the other. The Author of nature did not create the polype to be turned as we turn a glove; but he formed an animal whoſe viſcera were lodged in the thickneſs of the ſkin, and with powers to reſiſt the various accidents to which it was unavoidably expoſed by the nature of it's life; and the organization neceſſary for this purpoſe was ſo conſtructed, that the ſkin might be turned without deſtroying life.

Every portion of a divided polype has, like the vegetable bud, all the viſcera neceſſary to it's exiſtence; it can, therefore, live by itſelf, and puſh forth a head and tail, when placed end to end againſt another piece. The vegetation conſiſts in uniting the portions, the veſſels of each part increaſe in length, and a communication is ſoon formed between them, which unites the whole. The eaſe with which the parts unite, is, as has been obſerved before, probably owing to their gelatinous nature; for we find many ſimilar inſtances in tender ſubſtances. The ſolid parts of the embryo, as the fingers, unite in the womb; tender fruit and leaves may be alſo thus united.

A portion of theſe creatures is capable of devouring it's prey almoſt as ſoon as it is divided from the reſt. In the ſtructure of thoſe animals which are moſt familiar to us, a particular place is appropriated for the developement and paſſage of the embryo. But on the body of an animal, which, like a tree, is covered with prolific gems, it is not ſurprizing that the young ones ſhould proceed from it's ſides, like branches from a tree. The mother and her young ones form but one whole; ſhe nouriſhes them, and they contribute to her exiſtence, as a tree ſupports and is reciprocally ſupported by it's branches and leaves.

## OF THE HYDRA PALLENS.

The hydra pallens has been deſcribed only by M. Roeſel, Inſec. 3, Polyp. 465, Plate 76, 77; it is very ſeldom to be met with, is of a pale yellow colour, and grows ſmaller gradually from the bottom, the tail is ſomewhat round or knobbed, the arms are about the length of the body, of a white colour, and generally ſeven in number, apparently compoſed of a chain of globules; it brings forth the young from all parts of it's body. Linnæus defines it as hydra pallens tentaculis ſubſenis mediocribus. Pallas as hydra attenuata corpore flaveſcente, ſurſum attenuato.

## OF THE HYDRA HYDATULA.

The next in order is the hydra hydatula, which we have already defined from Linnæus as a hydra with four obſolete arms, and a veſicular body: it is ſpoken of by many medical writers, who are enumerated in the Syſtema Naturæ, p. 1321. It is deſcribed alſo by Hartman, miſc. nat. cur. dec. I. an. 7, obſ. 206, dec. II. an. 4, obſ. 73, as hydatis animata; alſo in the diſſert. de inf. viv. p. 50, n. 6, tænia hydatoidea. Pallas defines it as tænia hydatigena rugis imbricata corpore poſtice bulla lymphaticæ terminato. The deſcription I ſhall give the reader will be extracted from the Philoſophical Tranſactions, No. 193, by Dr. Tyſon, who names it lumbricus hydropicus.

In the diſſection of a gazella, or antelope, Dr. Tyſon obſerved ſeveral hydatides, or films, filled with water, about the bigneſs of a pigeon's egg, and of an oval form, faſtened to the omentum, and ſome in the pelvis, between the bladder of urine and the rectum;

and he then ſuſpected them to be a particular ſort of inſect, bred in animal bodies, or at leaſt the embryos or eggs of them, 1. Becauſe he obſerved them included in a membrane, like a matrix, ſo looſely, that by opening it with the finger, or a knife, the internal bladder, containing the ſerum or lympha, ſeemed no where to have any connection with it, but would very readily drop out, ſtill retaining it's liquor, without ſpilling any of it. 2. He obſerved that this internal bladder had a neck, or white body, more opake than the reſt of the bladder, and protuberant from it, with an orifice at it's extremity, by which, as with a mouth, it exhauſted the ſerum from the external membrane, and ſo ſupplied it's bladder, or ſtomach. 3. Upon bringing this neck near the candle, the neck moved and ſhortened itſelf. Fig. 1, Plate XXI. repreſents one of theſe watery bladders incloſed in it's external membrane, it's ſhape was nearly round, being only a little depreſſed, or flatted, as a drop of quickſilver will be by lying on a plane. In Fig. 2 the neck is better ſeen; the external membrane being taken off, an open orifice is found at it's extremity; it conſiſts of circular rings, or inciſures, which are more viſible when magnified, as in Fig. 3; it then appears granulated with a number of little eminencies all over the ſurface; the orifice at the extremity ſeems to be formed by retracting itſelf inwards, and upon trial it was found to be ſo; for in Fig. 4, the neck of this polype is repreſented magnified and drawn out it's whole length; on opening it there were found within the two ſtrings a a, which probably convey into the ſtomach the moiſture and nouriſhment, which the animal, by protruding it's neck, extracts from the external membrane.*

HYDRA

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* Hydra hydatula habitat in abdomine mammalium, ovium, ſuum, murium, &c, inter peritoneum et inteſtina. Veſica lymphatica, pellucida, magnitudine pruni, petiolata.

petiolata.

## HYDRA STENTOREA. FIG. 27 AND 28, PLATE XXII.

Tentaculis ciliaribus corpore infundibuliformi.

The arms of this hydra are rows of ſhort hairs, the body trumpet-ſhaped.

This ſpecies of hydra is very common, and has been deſcribed by almoſt every writer on theſe ſubjects; it is placed by Muller among the vorticellæ.

Vorticella ſtentorea caudata, elongata, tubæformis limbo ciliato. Muller animalcula infuſoria.

They are named by Mr. Baker and Mr. Trembley the funnel-like polype.

There are three ſpecies of them, which are of different colours, green, blue, and white. The white ones are the moſt common. It is neceſſary to obſerve them often, and in various attitudes, in order to obtain a tolerable idea of their ſtructure. They do not form cluſters, but adhere ſingly by their tail to whatever comes in their way; their anterior end is wider than the poſterior, and being round gives the animal ſomewhat of a funnel form, though it is not completely circular, having a ſort of ſlit, or gap, that interrupts the circle. The edge of this opening is furniſhed with a great number of little fimbrillæ, which by their briſk and continual

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petiolata corpore cylindrico, in cujus apice os, quod corpore compreſſo, movet tentacula vix manifeſta. Lin. Syſt. Nat. p. 1321.

tinual motions, excite a current of water; the ſmall bodies that float or ſwim near this current, are forced by it into the mouth of the little animal. Mr. Trembley ſays, that he has often ſeen a number of very ſmall animalcula fall one after another into the mouth, ſome of which were afterwards let out again at another opening, which he was not able to deſcribe.

They can faſhion their mouths into ſeveral different forms. If any thing touches them they ſhrink back and contract themſelves. They live independent of each other, ſwimming freely through the water in ſearch of their prey, and fix to any thing they meet with.

Theſe animals multiply by dividing themſelves, not longitudinally, nor tranſverſely, but ſloping and diagonal wiſe; the proceedings in nature continually varying in every new form of life. Of the two polypes produced by the diviſion of one, the firſt has the old head and a new tail, the other the old tail with a new head.

To make the deſcription more clear, Mr. Trembley called that with the old head the ſuperior polype, that with the new head the inferior one. The firſt particular that is obſervable in theſe polypes, when they are going to divide, is the lips of the inferior one; a tranſverſe and oblique ſtripe indicates the part where it is going to divide; the new lips are formed at about two-thirds of the length of the polype, reckoning from the head; the diviſion is made in a ſloping line, that goes about half way round the parent animal; theſe lips are at firſt diſcerned by a ſlow motion, which engages the attention of the obſerver. They then inſenſibly approach each other and cloſe, whereby a ſwelling is formed on the ſide of the polype, which is ſoon found to be a new head. When the ſwelling is conſiderably increaſed, the two polypes may be plainly diſtinguiſhed. The ſuperior one being now connected with the inferior one only by it's lower extremity, is ſoon detached from it, and ſwims away to fix itſelf on ſome convenient ſubſtance; the inferior one remains faſtened to the place where the original polype was fixed before the diviſion.

From the various modes by which different ſpecies of polypes are multiplied, we are led to form more exalted ideas of nature, and to ſee that the little we diſcover is but an exceeding ſmall part of her contents; we learn alſo to be more cautious in reaſoning from analogy, and laying down the known for a model to the unknown, becauſe we find that the operations in nature are varied ad infinitum.

The growth of the hydra ſuſca is very quick, but that of the hydra ſtentorea is much more ſo. The progreſs of the fœtus is always more rapid than that of the infant and adult animal; but in theſe organized atoms, the evolution is ſo rapid, as to appear almoſt like an immediate creation.

Fig. 28 repreſents the hydræ ſtentoreæ, or funnel-polype, fixed to the under ſide of a piece of ſome vegetable ſubſtance; they are in this figure of their natural ſize.

Fig. 27, the ſame polype magnified; the different forms they aſſume are alſo ſeen here, ſometimes ſhort and thick as at m m, long as at n, nearly globular as at o, extended to the full ſize as at k, ſeen as contracted at i. The fimbrillæ, or little hairs, may be ſeen in moſt of the attitudes, except thoſe of l.

## OF THE HYDRA SOCIALIS.

HYDRA SOCIALIS MUTICA TOROSA RUGOSA. Fig. 11, Pl. XXI.

Bearded thick and wrinkled.

This ſpecies of hydra has been deſcribed by many writers. It is the vorticella ſocialis of Muller, who defines it as vorticella caudata, aggregata, clavata; diſco obliquo Muller Animalcula infuſoria, p. 304. Pallas makes it a brachionus, Pall. Zooph. 53.

In Fig. 11 theſe animals are repreſented as conſiderably magnified; they appear like a circle, ſurrounded with crowns, or ciliated heads, tied by ſmall thin tails to a common center, from whence they advance towards the circumference, where they turn like a wheel, with a great deal of vivacity and ſwiftneſs, till they occaſion a kind of whirlpool, which brings into it's ſphere the proper food for the polype. When one of them has been in motion for a time, it ſtops, and another begins; ſometimes two or three may be perceived in motion together. They are often to be found ſeparate, with the tail ſticking in the mud. The body contracts and dilates very much, ſo as ſometimes to have the appearance of a cudgel, at others to aſſume almoſt a globular form. The young polypes of this ſpecies have been ſometimes taken for the hydra ſtentorea.

## OF THE VORTICELLÆ.

We now come to another diviſion of theſe animals, to which later writers have given the name of vorticellæ, which we ſhall therefore adopt, as we think it behoves every man to maintain that order in ſcientific arrangement which is not inconſiſtent with truth, except he can produce another arrangement more expreſſive of the nature of the objects it is deſigned to diſcriminate.

The variety that may be obſerved in theſe minute animals, confirms a principle, which the more it is looked into, the more it will be found to accord with the general operations in nature, namely, that there is always a pre-exiſtent principle of life neceſſary to the organization both of animals and vegetables; that the alimentary and other particles which are added to, or apparently belong to them, produce nothing of themſelves, they are incapable of forming the leaſt fibre, but they are able to become conſtituent parts of one organical whole, and the inſtruments whereby the forming principle is manifeſted, and rendered capable of acting upon certain orders of creatures.

### VORTICELLA.

Animal, calyce vaſculoſo; ore contractili ciliato, terminali ſtirps fixa.

A ſmall animal, with a vaſcular cup; the mouth is at one end ciliated, and capable of being contracted, the ſtem fixed.

## VORTICELLA ANASTATICA.

Vorticella anaſtatica, compoſita, floribus campanulatis ſtirpe multiflora rigeſcente, ſee Fig. 13, 14, 15, 16, Plate XXI.

Vorticella anaſtatica, compound, with bell-ſhaped flowers, and a rigid ſtem.

Cluſtering polype, ſecond ſpecies, Trembley, Philoſ. Tranſ. vol. xliv. part 2, p. 643.

Theſe polypes form a group reſembling a cluſter; or more properly an open flower; this flower, or cluſter, is ſupported by a ſtem, which is fixed by it's lower extremity to ſome of the aquatic plants, or extraneous bodies, that are found in the water; the upper extremity forms itſelf into eight or nine lateral branches, perfectly ſimilar to each other; theſe have alſo ſubordinate branches, whoſe collective form much reſembles that of a leaf. Every one of theſe aſſemblages is compoſed of one principal branch, or nerve, which makes with the main ſtem of the cluſter an angle ſomewhat greater than a right one; from both ſides of this nerve the ſmaller lateral branches proceed; theſe are ſhorter the nearer their origin is to the principal branch.

At the extremity of the principal branch, and alſo of all the lateral ones there is a polype or vorticella. There are others on both ſides of the lateral twigs, but at different diſtances from their extremity. Theſe polypes are all exceeding ſmall, and of a bell-like figure; near their mouth a quick motion may be diſcerned, though not with a ſufficient diſtinctneſs to convey an adequate idea of it's cauſe; upon the branches of theſe cluſters are round bodies, which will be more particularly deſcribed preſently.

Every cluſter has eight or nine of theſe branches, or leaves; they do not all proceed from the ſame point, but the points from whence they ſet out are not far aſunder; each of theſe branches is bent a little inwards, ſo that all of them taken together form a kind of ſhallow cup. If the eye is placed right over the baſe of this cup, the appearance of the whole eight or nine branches is like unto that of a ſtar, with ſo many rays proceeding from the center. If the cluſter is ſlightly touched, all the branches inſtantly fold up, and form a ſmall round maſs. The ſtem which ſupports the cluſter contracts alſo at the ſame time, folding up like a workman's meaſuring rule, that conſiſts of three or four joints. This extraordinary aſſemblage conſtitutes one organized whole, formed of a multitude of ſimilar and particular ones. A new ſpecies of ſociety, in which all the individuals are members of each other in the ſtricteſt ſenſe, and all participate of the ſame life.

A few days after one of theſe cluſters is formed, ſmall round bodies, or bulbs, may be perceived to protrude in ſeveral places from the body of the branch; theſe grow very faſt, and arrive at their greateſt growth in two or three days. The bulbs detach themſelves from the branches out of which they ſpring, and go away, ſwimming till they can ſettle upon ſome ſubſtance which they meet with in the water, and to which they fix themſelves by a ſhort pedicle; the bulbs are then round, only a little flatted on the under ſide, the pedicle continues to lengthen gradually for about twenty-four hours, during the ſame time the bulbs alſo change their figure, and become nearly oval. There are in a cluſter but few of theſe bulbs compared with the number of the vorticellæ, neither do all the bulbs come out at the ſame time. The bulb then divides lengthways into two ſmaller ones, but which are ſtill much larger than the vorticellæ themſelves. It is not long before theſe are ſeparated like the firſt, and thus form four bulbs on the ſame ſtalk; theſe again divide themſelves, and form eight, which again ſubdivide, and conſequently make ſixteen. They are all connected with the ſtalk by a proper pedicle, but they are not all of an equal ſize; the largeſt continue to divide, and the ſmalleſt begin to open, and take the bell-formed ſhape. Mr. Trembley obſerved from one round bulb, in about twenty-four hours, by repeated diviſions, one hundred and ten vorticellæ to be formed.

It has been aſked with propriety, what plant, or what animal, could have led us to expect an exiſtence and mode of propagation ſimilar to that of the vorticella anaſtatica?

Fig. 13 repreſents one branch of the vorticella anaſtatica; on this branch, beſides the vorticellæ which are of a bell-like form, ſome of thoſe round bodies from which they firſt ſpring, and by which they are ſo remarkably diſtinguiſhed from many other ſpecies, may be ſeen.

Fig. 14 repreſents one of the globular bodies, after it has parted from the cluſter, and has fixed itſelf to ſome other body, and after the globule itſelf and it's pedicle have begun to lengthen.

Fig. 15 repreſents the two bodies that were formed by the parting of that which is repreſented in Fig. 14.

Fig. 16 repreſents four that were formed by the ſeparation of the two bulbs, repreſented in the foregoing figure.

### VORTICELLA PYRARIA.

Compoſita, floribus muticis obovatis, tentaculis bigeminis ſtirpe ramoſa, Fig. 25 and 26, Plate XXII. Compound, with beardleſs oval florets, two double arms, the ſtem branched. Lin.

It is ſomewhat of a pear ſhape, the baſe is pellucid, the top truncated; the lateral arms, which are a pair on each ſide, cannot be diſtinguiſhed without ſome attention; they are ſometimes to be ſeen diſengaged from the pedicle, and rolling ſwiftly in a kind of circle.

### VORTICELLA CRATÆGARIA.

Vorticella compoſita, floribus muticis globoſis, tentaculis binis, ſtirpe ramoſa, Fig. 40, Plate XXII. Compound, with globous naked florets, two tentacules, and a branched ſtem.

Theſe vorticellæ are to be found in the month of April, both in the mud, and upon the tail of the monoculus quadricornis; they are generally heaped together in the manner in which they are repreſented in the figure; they are of a ſpherical form, and united to one common ſtalk. They are alſo often to be found without any pedicle, the body is rather contracted, the aperture is circular, and ſurrounded with a marked margin; it has two ſmall arms; with a deep magnifier, a vehement rotatory motion may be ſeen; they ſometimes ſeparate from the community, and go forwards in a kind of ſpiral line, and then in a little time come back again to the reſt.

Fig. 40 repreſents a parcel of theſe vorticellæ united together.

Among the other authorities for this animal, M. Linnæus refers to Mr. Baker's deſcription of the mulberry inſect, "Employment for the Microſcope," p. 348, which, as it differs a little from the preceding account, we ſhall inſert here. That from which his drawing was made, and which he has deſcribed, was found in a ditch near Norwich; he called it the mulberry inſect, from the reſemblance it bore to that fruit; though the protuberances that ſtand out round it are more globular than thoſe of a mulberry; it is to be ſeen rolling about from one place to another, and is probably a congeries of animalcula; they are to be met with in different numbers of knobs, or protuberances, ſome having fifty or ſixty, others more or leſs down to four or five. The manner of moving is the ſame in all. They are generally of a pale yellow.

### VORTICELLA OPERCULARIA, FIG. 29, PLATE XXII.

Vorticella compoſita, floribus muticis ovalibus, ſtirpe ramoſa. Compound, with naked oval florets, and a branched ſtem.

Theſe vorticellæ are of a lemon ſhape, and are generally found in cluſters, branching out from a ſtem, which moſtly adheres to ſome convenient ſubſtance.

That ſpecies of them which is deſcribed by Mr. Baker had a very ſhort pedicle, and the animals were much longer than thoſe which are repreſented at Fig. 29, Plate XXII. There was no main ſtem, but all the pedicles were joined in one center, round which the animals extended themſelves as ſo many radii, forming a very pleaſing figure.

The mouths of theſe animalcula are not ciliated, but they are furniſhed with a round aperculum, or cover, connected by a long ligament, or muſcle, which extends downwards through the body, and is affixed within ſide of it, near the tail. This ligament may be contracted or dilated, ſo that the cover may be removed to ſome diſtance from the mouth; in this ſituation ſeveral ſhort hairs may be found to radiate from it; theſe have a vibratory motion, by which they excite a current of water, moſt probably to draw in the proper nouriſhment, after which they ſhut or pull down the cover, which they again extend at pleaſure; when the cover is pulled cloſe down, the mouth contracts, and no hairs are to be ſeen.

Fig. 29 repreſents the vorticella opercularia, ſ the operculum removed at ſome diſtance from the mouth, at t, it is nearly cloſe at r, the mouth contracted, the cover drawn in, and no hairs to be ſeen; u a part of the ſtalk, from which ſome of the animalcula are ſeparated.

## VORTICELLA UMBELLARIA.

Vorticella compoſita, floribus ciliatis globoſis muticis, ſtirpe umbellata, Fig. 30, Plate XXII. Compound, with ciliated globous naked florets, and an umbellated ſtem.

Vorticella acinoſa, ſimplex, globoſa, granis nigricantibus, pedunculo rigido. Muller Animal Infuſ. p. 319.

We often find in divers places, upon water, plants, and other bodies in the water, a whitiſh ſubſtance, that looks like mould; plants, pieces of wood, ſnail ſhells, &c. are often entirely covered over with this ſubſtance. If we examine any of theſe by the microſcope, we ſhall find ſuch motions as will induce us to think them an aſſemblage of living animals, minute bodies, ſeverally fixed to the extremities of ſmall ſtems, or pedicles, many of which are often ſo united as to form together a ſort of branches, or cluſters, from whence they have been termed cluſtering polypes, or des polypes en bouquet.

Theſe cluſters are larger or ſmaller, according to the ſpecies of the vorticellæ which form them, and according to the concurrence of many other circumſtances. To get a clear idea of the figure of theſe animals, it is beſt to obſerve the ſmaller cluſters, as in the larger they are often rendered leſs diſtinct on account of the number.

The length of thoſe which are repreſented at Fig. 30, is about the 240th of an inch; they are of a bell-ſhape. The anterior part a c generally appears open, the poſterior part is fixed to a ſtem, or pedicle, b e; it is by the extremity of this pedicle that the vorticella faſtens itſelf to any ſubſtance. It appears in the microſcope of a browniſh colour, excepting at the ſmaller end b, where it is tranſparent, as well as the whole pedicle b e. When the anterior part a c is open, a very lively motion may be perceived about it's edges; and when it preſents itſelf in a particular manner, ſomething very much reſembling the little wheels of a mill, moving with great velocity, may be diſcovered on both ſides of the edges of this anterior part.

Theſe vorticellæ are able to contract themſelves ſuddenly. They may be made to do this, either by touching them, or moving the ſubſtance to which they are affixed. When they contract, the edges of the anterior parts are drawn quite into the body; on reſuming their former poſture, the edges may be ſeen to come forth, and put themſelves in motion as before. Minute ſubſtances that float in the water are often forced down into theſe openings, and ſometimes are thrown out again.

They are capable of ſwimming about ſingly, but their form is in that caſe conſiderably different from that which they have when they are fixed. To ſee regularly in what manner the cluſters are formed, and in what way theſe little creatures multiply, it is beſt to obſerve one that is fixed by itſelf.

The pedicle of a ſingle vorticella is at firſt ſhort, but it ſoon grows longer, and then begins to multiply, that is, to divide, or ſplit itſelf in two lengthways. To effect this, the lips are firſt drawn into the body, the anterior part cloſes and becomes round, and loſes it's bell ſhape, the motion about the lips ceaſes, though a ſmall degree of motion may be perceived within the body. The anterior end flattens gradually, and ſpreads wider in proportion as it grows ſmaller. It then gradually ſplits down the middle, that is, from the middle of the head to the pedicle, ſo that in a little time two ſeparate round bodies appear to be joined to the end of the pedicle, that before ſupported but one.

The mouth, or anterior part of each of theſe bodies, now opens by degrees; and in proportion as they open, the lips of the new vorticella begin to diſplay themſelves. The motion before ſpoken of may then alſo be perceived. Indeed it is the beſt time of obſerving it; it is at firſt ſlow, but more rapid in proportion as the mouth opens, when it is as ſwift as that of the vorticella before it began to divide, and we may now look upon it as completely formed. A vorticella is generally about one hour in dividing itſelf.

The lower of the three drawings, Fig. 30, repreſents two vorticellæ joined by their poſterior extremity to one pedicle; ſoon after the diviſion, each vorticella begins to ſhew a pedicle of it's own.

Fig. 30 repreſents a cluſter of eight vorticellæ; by this figure we may form ſome idea in what manner the pedicles are diſpoſed as their number increaſes; there were at firſt only two at b, whoſe branches lengthened to d, and then each of them was divided into two, now forming four; theſe again lengthened and reached i, when they were again ſubdivided, as in the figure.

The reader will join with M. Bonnet in admiring the group of wonders afforded by a ſingle ſpot of mouldineſs. What unforeſeen, varied, and intereſting ſcenes are preſented within ſo ſmall a compaſs! what a theatre is exhibited to a thinking mind! But our abode is ſo recluſe, that we have but a glimmering view of it: how great would our aſtoniſhment be, if the whole ſpectacle was diſcloſed to us at once, and we were enabled to penetrate into the interior ſtructure of this wonderful aſſemblage of living atoms!

Our eyes ſee only the groſs part of the decorations, whilſt the machines that execute them remain in impenetrable darkneſs! Who ſhall enlighten this profound obſcurity, or dive into an abyſs where reaſon is loſt, or draw from thence the treaſures of wiſdom concealed within it? Let us learn to be content with the ſmall portion that is communicated to us, and contemplate with gratitude the firſt traces of human underſtanding that are imparted to us in theſe diſcoveries.

## VORTICELLA BERBERINA.

Vorticella compoſita, floribus ovalibus muticis, ſtirpe ramoſa. Compound, with oval beardleſs florets.

This is a ſpecies of the vorticellæ, which reſemble the preceding one in many reſpects, particularly in being multiplied in the ſame manner, that is, by dividing, or ſplitting, according to it's length.

They are more ſlender than the vorticella umbellaria; the branches of the cluſters are tranſparent. When many of them are together, they appear of a changeable violet colour; the cluſters are not unlike a ſprig of ſpun glaſs. The motion of the lips is not ſo eaſily diſtinguiſhed as in the foregoing ſpecies, though it may be obſerved in theſe whilſt they are opening and completing their formation. For at theſe times the motion is but ſlow, whereas it becomes afterwards very quick in thoſe that are arrived at a ſtate of perfection.

All the cluſter vorticellæ detach themſelves from time to time from the ſtem, and from theſe they ſwim about till they fix again upon ſome convenient ſubſtance; the branches, when deſerted, bear no more vorticellæ.

## VORTICELLA DIGITALIS.

Vorticella compoſita, floribus cylindricis, uniſulcatis ſemiclauſis, ſtirpe ramoſa, Fig. 31, Pl. XXII. Compound, with cylindrical florets.

Vorticella compoſita, cylindrica, cryſtallina, apice truncata et fiſſa, pedunculo fiſtuloſo ramoſa. Muller Animal Infuſ. p. 327.

This ſpecies of the vorticella is very ſcarce, it ſeems only to have been ſeen by Roeſel, who found it on the monoculus quadricornis, till 1784, when it was diſcovered by Mr. Muller, who had ſought for it ſeveral years before in vain.

The body is cylindrical, cryſtalline, and appears almoſt empty; it has three pellucid points diſpoſed lengthways, the apex is truncated in an oblique direction, the margin bent back. The upper part contracts itſelf, and the margin then aſſumes a conical ſhape, with a convex ſurface; there are in general but few branches from the principal ſtem, and theſe are ſhort and thick; it excites an undulatory motion, but no hairs, nor any rotatory motion, have been diſcovered. Fig. 31, o and n, repreſents the vorticella adhering to the monoculus quadricornis.

## VORTICELLA CONVALLARIA.

Simplex, gregaria, flore campanulata mutico, tentaculis bigeminis, ſtirpe fixa, Fig. 39, Pl. XXII. Simple, but gregarious, the florets bell-ſhaped, with two pair of little arms, and a fixed ſtem.

Vorticella ſimplex, campanulata, pedunculo retortili. Muller Animal Infuſ.

Theſe vorticellæ, or bell animals, as they are termed by Mr. Baker, are generally found adhering to ſome ſubſtance in the water; they are repreſented here as found by M. Roeſel, fixed to a curious cornu ammonis, with points projecting from the back. To the naked eye they appear only as ſo many little white points, but under a microſcope, as little bells, agitating the water to a conſiderable diſtance. The ſtems of theſe have a particular motion, they draw themſelves up, and ſhorten all at once, taking the form of a ſpiral wire, or ſcrew; in a moment after they again reſume their former ſhape, ſtretching themſelves out ſtrait as before. Many of them may be ſeen at times adhering to each other by their tails; the cilia, which are two on each ſide of the mouths, are very ſeldom to be perceived.

## VORTICELLA URCEOLARIS. FIG. 33, 34, 35, PLATE XXII.

Simplex, pedunculata, ore dentato. Single, with a ſhort tail, and toothed mouth.

Brachionus capſularis teſta ovata apice ſexdentata baſi inciſa, cauda longa bicuſpi. Muller Animal Infuſ. p. 356.

To the naked eye it appears as a white moveable point: but when examined by the microſcope, a tail, projecting from the lower part, is diſcovered, and a double rotatory inſtrument is ſeen, which it can conceal or diſcover at pleaſure. It has been ſeen and deſcribed by moſt microſcopical writers; but as Mr. Baker's ſeems to us to be the moſt perfect, we ſhall principally follow his account of it.

He diſcovered three ſpecies of them, two of which are included under the vorticella urceolaris. Fig. 33, 34, 35, are of the firſt ſpecies; Fig. 36, 37, 38, are of the ſecond kind. The firſt ſort, when extended, is about twice as long as it is broad. It is contained in a ſhell; the fore-part of this is armed with four ſharp teeth, or points; the oppoſite ſide has no teeth, but is waved, or bent, in two places, like the form of a Turkiſh bow. At the bottom there is a hole, through which it puſhes the tail. It faſtens itſelf by this tail to any convenient ſubſtance, when it intends to uſe it's rotatory organs; but when it is floating in the water, and at all other times when not adhering to any body, it wags the tail backwards and forwards ſomething like a dog.

We may conſider it as divided into a head, thorax, and abdomen; each of which may be extended and contracted conſiderably: it can by dilating all three protrude the head beyond the ſhell, or by contracting them, draw the whole body within the ſame.

The head when extended divides itſelf into two branches, between which another part, a kind of proboſcis, is puſhed out; at the end of this are two fibrils, that appear when they are at reſt like a broad point, but which can be moved to and from each other very briſkly with a vibratory motion, ſee Fig. 33.

The form and ſituation of the two branches is ſometimes changed, the ends thereof becoming more round, and the vibratory motion is altered to a rotatory one: this alteration is repreſented at Fig. 34: the head alſo appears in this figure. The thorax is annexed to the lower part of the head, it is muſcular; within it there is a moving inteſtine, which has been ſuppoſed to be either the lungs or the heart of the little creature, ſee b, Fig. 33 and 34.

A communication is formed between the thorax and the abdomen by means of a ſhort veſſel c, whoſe alternate contractions and dilatations occaſion the abdomen to riſe and fall alternately, having at the ſame time a ſort of periſtaltic motion. The food is conveyed through this veſſel into the abdomen, where it is digeſted; it is then diſcharged by the anus, which is placed near the tail.

The tail has three joints, and is cleft or divided at the extremity, by which means it can better faſten itſelf to ſuitable objects. It is in general projected from the lower end of the ſhell, moving nimbly to and fro, ſerving the animal as a rudder when it is ſwimming to direct it's courſe.

When the water in which the little animal is placed is nearly dried away, or when it has a mind to compoſe itſelf to reſt, it contracts the head and fore-part of the body, and brings them down into the ſhell, and pulls the tail upwards, ſo that the whole of this minute creature is contained within the ſhell, ſee Fig. 35. The ſhell is ſo tranſparent that the terminations cannot be eaſily diſtinguiſhed when the animal is extended; but whatever is tranſacted within the ſhell, is as plain as if there was no ſubſtance between the eye and the interior parts.

Fig. 36, 37, 38, exhibit the appearance of another ſpecies of theſe animals, which differs from the foregoing kind. This has alſo a head, a thorax and abdomen, but then they are not ſeparated by a gut or intermediate veſſel, as in the former, but are joined immediately together, and at the place where in the firſt kind a moveable inteſtine was ſeen; in this a muſcle, moſt probably the heart, may be diſcovered; it has a regular ſyſtole and diaſtole: this part is intended to be ſhewn at a, Fig. 36, 37, 38. Like the other it draws the head and tail within the ſhell, which then appears to have ſix teeth or ſpikes on one ſide, and two on the other: it very ſeldom protrudes it's head ſo far out as the other; ſometimes the fibrillæ may be ſeen within the margin of the ſhell.

Both ſpecies carry their young in an oval integument or bag, faſtened externally to the lower part of the ſhell, ſomewhere about the tail; theſe bags are ſometimes opake at one end, and ſeemingly empty at the other, ſee Fig. 34: ſometimes the middle is opake, with a tranſparent margin, ſee Fig. 36.

It is highly entertaining to ſee a young one burſt it's integument, and gradually force it's way out; in performing this operation, it is much aſſiſted by the motion of the tail of the parent. The head part comes out firſt, it then ſets it's rotatory organ in motion,

motion by which it is completely diſengaged, leaving the integument behind, which the vorticella freed itſelf from by repeated ſtrokes with it's tail. A young one almoſt diſengaged is ſeen at b, Fig. 38; another embryo, c, was left adhering to the ſhell.

There are four more ſpecies of the vorticella mentioned by Linnæus, which are the vorticella encrinus, the vorticella polypina, the vorticella ſtellata, and the vorticella ovifera, which do not come properly within our plan. The vorticella polypina will be deſcribed hereafter. There is, however, another little animal, of which we have given a figure in Plate XXII. and which Linnæus, in a former edition of the Syſtema Naturæ, placed among the hydræ, but which he has ſince removed, and placed amongſt the tubularia; and as I do not feel myſelf competent to controvert the propriety or impropriety of the former or preſent arrangement, the little creature muſt here take a ſolitary ſituation, and ſtand without a companion.

### TUBULARIA CAMPANULATA. FIG. 32, PLATE XXII.

Reptans, tubis campanulatis. Creeping, with campanulated tubes.

It is called by Mr. Baker the bell-flowered, or plumed animal.

Theſe little creatures dwell in colonies together, from ten to fifteen in number, living in a kind of ſlimy mucilaginous caſe, which, when expanded in the water, has ſome reſemblance to a bell with it's mouth upwards. Theſe bells, or colonies, are to be found adhering to the large leaves of duck-weed and other aquatic plants.

The bell, or caſe, which theſe animals inhabit, being very tranſparent, all the motions of it's inhabitants may be diſcerned diſtinctly through it. There are ſeveral ramifications, or ſmaller bells, proceeding from the larger one; in each of theſe there is an inhabitant. The opening at the top of theſe bells is juſt large enough for the creature's head and a ſmall part of it's body to be thruſt out from it, the reſt remaining in the caſe, into which it alſo draws the head on the leaſt alarm.

Beſides the particular and ſeparate motions which each of theſe creatures is able to exert within it's caſe, and independent of the reſt, the whole colony has a power of altering the poſition of the bell, and removing it from one place to another. Theſe animalcula ſeem not to like to dwell in ſocieties whoſe number exceeds fifteen; when the colony happens to increaſe in number, the bell may be obſerved to ſplit gradually, beginning from about the middle of the upper extremity, and proceeding downwards towards the bottom, till they at laſt ſeparate and become two colonies, independent of each other.

The arms are very near each other; ſixty may often be counted in one plume, having each the figure of an Italic *ſ*, one of whoſe hooked ends is faſtened to the head; and all together, when expanded, compoſe a figure ſomewhat like a horſeſhoe, convex on the ſide next the body, but gradually opening and turning outwards, ſo as to leave a conſiderable diſtance within the outer extremities of the arms. When the arms are thus extended, the creature, by giving them a vibratory motion, can produce a current in the water, which brings the animalcula, and other minute bodies that are floating near it, into it's mouth, ſituated between the arms. The food, if agreeable to the creature, is ſwallowed; if not, it is rejected by a contrary motion. As the ſkin is tranſparent, the animal may be ſeen very plain when it has retired within the tube.

The body is about one-eighth of an inch long, without reckoning the plume, which is about the ſame length. It is cylindrical, and the ſkin is very tranſparent. The plume is only a continuation of this tranſparent ſkin, it is very broad in proportion to the body, and of a remarkable figure; the baſe is of the ſhape of a horſeſhoe, from this baſe the arms project, they bend rather outwards. The plume which they form gives them a reſemblance to ſome flowers. The arms may be compared, from their fineneſs and tranſparency, to very fine threads of glaſs. The baſe of the plume is grooved, and is fixed to the animal by the middle of the horſeſhoe which it forms, and it is here that there is an opening which ſerves as a mouth to the animal. The inteſtines are eaſily diſtinguiſhed through it's tranſparent ſkin; when it has juſt been eating, they are of a deep brown colóur. Three principal parts may be diſtinguiſhed, the oeſophagus e h i, the ſtomach f g, and the rectum f a.

The plumed polype is very voracious, devouring a great number of ſmall animals. The arms, when obſerved attentively with the microſcope, will be found to bend from moment to moment within ſide of the plume, and then riſe up again;

then another arm performs the ſame; thus by the continual motion of it's arms, it puts the water into violent agitation, and brings into it's mouth the food whereby it is nouriſhed.

In the inſide of theſe animals a ſmall oblong whitiſh body is formed, which is carried to the outſide, and remains fixed in a perpendicular direction to the body; many of theſe are formed daily, and of theſe oval bodies new animals are produced, exactly ſimilar to the parent.

If theſe minute bodies are eggs, they are of a ſingular kind, being deſtitute of any covering, and are neither membranaceous nor cruſtaceous; we cannot with propriety ſay the young ones are hatched from them; we can, however, perceive theſe oviform bodies to gradually unfold themſelves. The developement is accompliſhed in a few minutes, and an animalculum appears like the parent.

Mr. Trembley amaſſed a large quantity of theſe eggs, and carried them from England with him, keeping them quite dry; on putting them into water, they gradually developed, and became as perfect as the tubularia from which they proceeded.

There is a very great ſimilarity in the conſtruction of this little creature, and many of the marine polypes, who, like it, exiſt in tubes of the ſame growth with themſelves.

Fig. 32 repreſents three tubulariæ campanulatæ, or plumed polypes, very much magnified, namely, b f a c d d e h g i, which is out of it's cell; I B A C, which is within it's cell, and the young one, t u u s, which is out of it's cell; e h the oeſophagus, f g the ſtomach, a f the rectum, a c d d e the plume, conſiſting of the baſe e a c, which is but little ſeen, and the arms a d a d a d which proceed from the edges of this baſe; I B A C one of the animals drawn into it's cell, I A B the ſkin reverſed, in which the plume is contained; g o o threads which are fixed at one end to the inteſtines of the animal, by the other to the bottom of the cell.

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R. HINDMARSH,
Printer.
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# CHAP. VIII.

## OF THE ANIMALCULA INFUSORIA.

OUR knowledge of the microſcopic world is at preſent very contracted, but we know enough to give us high conceptions of it's concealed wonders, and to fill us with profound aſtoniſhment at the infinite variety of forms that are made recipient of life. A few of the inhabitants of this world have been diſcovered. The figure and apparent habits of life of theſe, reſemble ſo little thoſe with which we are more acquainted, that it is often difficult to find terms to expreſs what is preſented to the eye. It is highly probable that there are many gradations of exiſtence far below the minuteſt of thoſe which we obſerve with the microſcope; and though by this we are enabled to diſcover myriads of different creatures roving in the leaſt drop of water, as if it were a ſea, yet it is not unreaſonable to ſuppoſe that HE who has filled the immenſity of extent with ſuns and worlds, has peopled every particle of fluids with more minute beings than any apparatus of our's can perceive, agreeable to the ſublime ideas of the poet:

Gradual from theſe what num'rous kinds deſcend,
Evading even the microſcopic eye!
Full nature ſwarms with life; one wond'rous maſs
Of animals, or atoms organized,
Waiting the vital breath, when parent heaven
Shall bid his ſpirit blow. The hoary fen,
In putrid ſteams, emits the living cloud
Of peſtilence; thro' ſubterranean cells,
Where ſearching ſun-beams ſcarce can find a way,
Earth animated heaves. The flowery leaf
Wants not it's ſoft inhabitants. Secure,
Within it's winding citadel, the ſtone
Holds multitudes. But chief the foreſt boughs,
That dance unnumber'd to the playful breeze,
The downy orchard, and the melting pulp
Of mellow fruit, the nameleſs nations feed
Of evaneſcent inſects. Where the pool
Stands mantled o'er with green, inviſible,
Amid the floating verdure, millions ſtray.
Each liquid too, whether it pierces, ſoothes,
Inflames, refreſhes, or exalts the taſte,
With various forms abounds. Nor is the ſtream
Of pureſt cryſtal, nor the lucid air,
Tho' one tranſparent vacancy it ſeems,
Void of their unſeen people. Theſe, conceal'd
By the kind art of forming heaven, eſcape
The groſſer eye of man:

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Let no preſuming impious railer tax
Creative Wiſdom, as if aught was form'd
In vain, or not for admirable ends.
Shall little haughty Ignorance pronounce
His works unwiſe, of which the ſmalleſt part
Exceeds the narrow viſion of her mind?
As if upon a full proportion'd dome,
On ſwelling columns heav'd, the pride of art!
A critic fly, whoſe feeble ray ſcarce ſpreads
An inch around, with blind preſumption bold,
Should dare to tax the ſtructure of the whole.
And lives the man, whoſe univerſal eye
Has ſwept at once th' unbounded ſcheme of things;
Mark'd their dependance ſo, and firm accord,
As with unfaultering accent to conclude
That this availeth nought? Has any ſeen
The mighty chain of beings leſſening down
From infinite perfection to the brink
Of dreary nothing, deſolate abyſs!
From which aſtoniſh'd thought, recoiling, turns?
Till then alone let zealous praiſe aſcend,
And hymns of holy wonder, to that Power,
Whoſe wiſdom ſhines as lovely on our minds,
As on our ſmiling eyes his ſervant ſun.

THOMPSON.

Animalculum ſignifies a little animal, and therefore the term might be applied to every animal which is conſiderably inferior in ſize to ourſelves. It has been cuſtomary, however, to diſtinguiſh by this name only thoſe animals that are of a ſize ſo diminutive, that their true figure cannot be diſcerned without the aſſiſtance of glaſſes, and is more eſpecially applied to ſuch as are altogether inviſible to the naked eye, and cannot be perceived even to exiſt but by the aid of microſcopes.

By theſe we are brought into a new world, and numberleſs animals are diſcovered, which, from their minuteneſs, muſt otherwiſe for ever have eſcaped our obſervation: and how many kinds of theſe inviſibles there may be, is yet unknown; as they are diſcerned of all ſizes, from thoſe which are barely inviſible to the naked eye, to ſuch as reſiſt the action of the microſcope, as the fixed ſtars do that of the teleſcope, and with the greateſt powers hitherto invented, appear only as ſo many moving points.

The ſmalleſt living creatures our inſtruments can ſhew, are thoſe that inhabit the waters; for though animalcula, equally minute, may fly in the air, or creep upon the earth, it is ſcarce poſſible to get a view of them; whereas, water being tranſparent, and confining the creatures within it, we are enabled, by applying a drop of it to our glaſſes, to diſcover with eaſe a great part of it's contents.

It has been long known, that if ſeeds, herbs, or other vegetable ſubſtances, are infuſed in water, the water will ſoon be filled with an indefinite number of little animals. We find them, in general, moving in all directions with equal eaſe and rapidity, ſometimes obliquely, ſometimes ſtrait forwards, at other times circularly, one while rolling and turning round, and then running backwards and forwards through the whole dimenſions of the drop, as if in ſport; at other times attacking with avidity the little heaps of matter they meet with in their way. They know how to avoid with dexterity any obſtacles that would interrupt their motion, and even to avoid one another; you may ſee hundreds in motion in a drop of water, that never ſtrike againſt each other; ſometimes they will ſuddenly change the direction in which they are moving, and take one diametrically oppoſite thereto. By inclining the glaſs on which the drop of water is laid, it may be made to move in any direction; the animalcula in the drop will ſwim as eaſily againſt the ſtream as with it.

If the water begins to evaporate, and the drop to grow ſmaller, they flock impetuouſly towards the remaining fluid; an anxious deſire of attaining this momentary reſpite of life is very viſible, as well as an uncommon agitation of the organs by which they imbibe the water. Theſe motions grow languid as the water fails, till they at laſt ceaſe. If they are left dry for a little time, it is impoſſible to re-animate them by giving them freſh water.

Animalcula and inſects will ſupport a great degree of cold, but both one and the other periſh when it is carried beyond a certain point. The ſame degree of heat that deſtroys the exiſtence of inſects, is fatal to animalcula; as there are animalcula produced in water at the freezing point, ſo there are inſects which live in ſnow.

If the ſmalleſt drop of urine is put into a drop of water, where theſe animalcula are roving about, apparently happy and eaſy, they inſtantly fly to the other ſide, but the acid ſoon communicating itſelf to this part, their ſtruggles to eſcape are increaſed, but the evil alſo increaſing, they are thrown into convulſions, and ſoon expire.

Among animalcula, as in every other part of nature, there is always a certain proportion preſerved between the ſize of the individuals and their number. There are always feweſt amongſt the larger kinds, but they increaſe in number as they diminiſh in ſize, till of the laſt or loweſt to which our powers of magnifying will reach, there are myriads to one of the larger. Like other animals, they increaſe in ſize from their birth till they have attained their full growth. When deprived of food, they grow thin and periſh, and different degrees of organization are to be diſcovered in their ſtructure.

The birth and propagation of theſe microſcopic beings is as regular as that of the largeſt animals of our globe; for though their extreme minuteneſs prevents us, in moſt caſes, from ſeeing the germ from which they ſpring, yet we are well aſſured, from numerous obſervations, that the manner in which they multiply is regulated by conſtant and invariable laws.

We have ſeen that different ſpecies of the hydra and vorticella multiply and increaſe by natural diviſions and ſubdiviſions of the parent's body; this manner of propagation is very common among the animalcula in infuſions, though with many remarkable varieties. Some multiply by a tranſverſe diviſion, a contraction takes place in the middle, forming a kind of neck, that becomes ſmaller every inſtant, till they are enabled by a ſlight degree of motion to ſeparate from each other. Theſe animalcula, in general, ſtudiouſly avoid each other; but when they are in the labour of multiplication, and the diviſion is in great forwardneſs, it is not uncommon to ſee one of them precipitate itſelf on the neck of the dividing animalcula, and thus accelerate the ſeparation.

Another ſpecies, when it is on the point of multiplying, fixes itſelf to the bottom of the infuſion; it then forms an oblong figure, afterwards becomes round, and begins to turn rapidly, as if upon an internal center, continually changing the direction of it's rotatory motion; after ſome time, we may perceive two lines on the ſpherule, forming a kind of croſs; ſoon after which, the animalculum divides into four, which grow, and are again ſubdivided.

Some multiply by a longitudinal diviſion, which in one kind begins in the fore-part, and others in the hind-part; from another kind a ſmall fragment is ſeen to detach itſelf, which very ſoon acquires the form of the parent animalculum. Laſtly, ſome propagate in the ſame manner as thoſe we deem more perfect animals.

From what has been ſaid, it appears clearly that their motions are not purely mechanical, but are produced by an internal ſpontaneous principle, and that they muſt therefore be placed among the claſs of living animals, for they poſſeſs the ſtrongeſt marks, and the moſt decided characters of animation; and conſequently, that there is no foundation for the ſuppoſition of a chaotic and neutral kingdom, which can only have derived it's origin from a very tranſient and ſuperficial view of theſe animalcula.

It may alſo be further obſerved, that as we ſee that the motions of the limbs, &c. of the larger animals are produced by the mechanical conſtruction of the body, and the action of the ſoul thereon, and are forced by the ocular demonſtration which ariſes from anatomical diſſection, to acknowledge this mechaniſm which is adapted to produce the various motions neceſſary to the animal; and as when we have recourſe to the microſcope, we find thoſe pieces which had appeared to the naked eye as the primary mechanical cauſes of the particular motions, to conſiſt themſelves of leſſer parts, which are the cauſes of motion, extenſion, &c. in the larger; when the ſtructure can therefore be traced no further by the eye or glaſſes, we have no right to conclude, that the parts which are inviſible are not equally the ſubject of mechaniſm: for this would be only to aſſert in other words, that a thing may exiſt becauſe we ſee and feel it, and have no exiſtence when it is not the object of our ſenſes.

The ſame train of reaſoning may be applied to microſcopic inſects and animalcula; we ſee them move, but becauſe the muſcles and members which occaſion theſe motions are inviſible, ſhall we infer that they have not muſcles, with organs appropriated to the motion of the whole and it's parts? To ſay that they exiſt not, becauſe we cannot perceive them, would not be a rational concluſion. Our ſenſes are indeed given us, that we may comprehend ſome effects; but then we have alſo a mind with reaſon beſtowed upon us, that from the things which we do perceive with our ſenſes, we may deduce the nature of thoſe cauſes and effects which are imperceptible to the corporeal eye.

Meſſrs. Buffon, Needham, and Baron Munckhauſen, have conſidered this part of animated nature in ſo different a light from other writers, that we cannot with propriety entirely paſs them over. Mr. Needham imagined that there was a vegetative force in every microſcopical point of water, and every viſible filament of which the whole vegetable contexture conſiſts; that the ſeveral ſpecies of microſcopic animals may ſubſide, reſolve again into gelatinous ſilaments, and again give leſſer animals, and ſo on, till they can be no further purſued by glaſſes. That agreeable to this idea, every animal, or vegetable ſubſtance, advances as faſt as it can in it's revolution, to return by a ſlow deſcent to one common principle, whence it's atoms may return again, and aſcend to a new life. That notwithſtanding this, the ſpecific ſeed of one animal can never give another of a different ſpecies, on account of the preparation it muſt receive to conſtitute it this ſpecific ſeed.

M. Buffon aſſerts, that what have been called ſpermatic animals, are not creatures really poſſeſſing life, but ſomething proper to compoſe a living creature, diſtinguiſhing them by the name of organic particles, and that the moving bodies which are to be found in the infuſions, either of animal or vegetable ſubſtances, are of the ſame nature.

Baron Munckhauſen ſuppoſed that the ſeeds of muſhrooms were firſt animals, and then vegetables; and this becauſe he had obſerved ſome of the globules in the infuſions of muſhrooms, after moving ſome time, to begin to vegetate.

It might be ſufficient in the firſt inſtance to obſerve, that Meſſ. Needham and Buffon, by having recourſe to a vegetative force, and organic particles, to account for the exiſtence, and explain the nature of animalcula, and the difficulties of generation, have ſubſtituted words in the place of things, and that we are no gainers by the ſubſtitution, unleſs they explain the nature of theſe powers. But to this we may add, that all thoſe who have examined the ſubject with accuracy and attention, as Bonnet, De Sauſſure, Baker, Wriſberg, Spalanzane, Haller, Ellis, Muller, Leder Muller, Corti, Roffredi, &c. diſagree with the foregoing gentlemen, proving that they had deceived themſelves by inaccurate experiments, and that one of them, M. Buffon, had not ſeen the ſpermatic animals he ſuppoſed himſelf to be deſcribing, inſomuch that Mr. Needham was at laſt induced to give up his favorite hypotheſis.

To this we may add, that though we can by no means pretend to account for the appearance of moſt animalcula, yet we cannot help obſerving, that our ignorance of the cauſe of any phænomenon is no argument againſt it's exiſtence. Though we are not, for inſtance, able to account in a ſatisfactory manner for the origin of the native Americans, yet we ſuppoſe M. Buffon himſelf would reckon it abſurd to maintain, that the Spaniards on their arrival there found only ORGANIC PARTICLES moving about in diſorder. The caſe is the very ſame with the eels in paſte, to whoſe animation he objects. They are exceedingly ſmall in compariſon with us; but, with the ſolar microſcope, Mr. Baker has made them aſſume a more reſpectable appearance; ſo as to have a diameter of an inch and an half, and a proportionable length. They ſwam up and down very briſkly; the motion of their inteſtines was very viſible; when the water dried up, they died with apparent agonies, and their mouths opened very wide. Now, were we to find a creature of the ſize of this magnified eel gaſping in a place where water had lately been, we certainly ſhould never conclude it to be merely an ORGANIC PARTICLE, or fortuitous aſſemblage of them, but a fiſh. Why then ſhould we conclude otherwiſe with regard to the eel in it's natural ſtate, than that it is a little fiſh? In reaſoning on this ſubject, we ought ever to remember, that however eſſential the diſtinction of bodies into great and ſmall may appear to us, they are not ſo to the Deity, with whom, as Mr. Baker well expreſſes himſelf, " an atom is a world, and a world but as an atom."—Were the Deity to exert his power a little and give a natural philoſopher a view of a quantity of paſte filled with eels, from each of whoſe bodies the light was reflected as in the ſolar microſcope; our philoſopher, inſtead of imagining them to be mere organic particles, (as the paſte would appear like a little mountain,) he would probably look upon the whole as an aſſemblage of ſerpents, and be afraid to come near them. Whenever, therefore, we diſcover beings to appearance endowed with a principle of ſelf-preſervation, or whatever we make the characteriſtic of animals, neither the ſmallneſs of their ſize, nor the impoſſibility of our knowing how they came there, ought to cauſe us to doubt of their being animated.*

I ſhall here inſert ſome extracts of the experiments made by Mr. Ellis at the deſire of M. Linnæus, and which are a full refutation of thoſe made by M. Needham and B. Munckhauſen. By thoſe he made on the infuſions of muſhrooms in water, it appeared evidently that the ſeeds were put in motion by minute animals, which aroſe on the decompoſition of the muſhroom; theſe, by pecking at the ſeeds, which are little round reddiſh bodies, moved them about with great agility in a variety of directions, while the little animals themſelves were ſcarce viſible till the food they had eaten diſcovered them.

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* Encyclopædia Britannica, vol. 1, p. 456.

The ramified filaments, and jointed or coralloid bodies, which the microſcope diſcovers to us on the ſurface of moſt vegetable and animal infuſions, when they become putrid, and which were ſuppoſed by Mr. Needham to be zoophytes, were found by Mr. Ellis to be of that genus of fungi called mucor, many of which have been figured by Michelius, and deſcribed by Linnæus. Their vegetation is ſo quick, that they may be ſeen to grow and feed under the eye of the obſerver; other inſtances of ſimilar miſtakes in Mr. Needham's experiments may be ſeen in Mr. Ellis's paper, Philoſ. Tranſ. vol. lix. p. 138.

A ſpecies of mucor ariſes alſo from the bodies of inſects putrefying in water; this ſpecies ſends forth a maſs of tranſparent filamentous roots, from whence ariſe hollow ſeed veſſels; on the top there is a hole, from which minute globules often iſſue in abundance, and with conſiderable elaſtic force, which move about in the water. It will, however, be found, with a little attention, that the water is full of very minute animalcula, which attack theſe ſeeds, and thus prolong their motion; but after a ſmall ſpace of time they riſe to the ſurface, and remain there without any motion; a freſh quantity riſes up, and floating to the edge of the water, remains there inactive; but no appearance can be obſerved of detached and ſeparated parts becoming what is called microſcopic animalcula. Indeed, it is ſurprizing that Mr. Needham ſhould ever take the filaments of the moiſtened grains for any thing elſe than a vegetable production, a true ſpecies of mouldineſs.

On the 25th of May, Fahrenheit's thermometer 70°, Mr. Ellis boiled a potatoe in the New River water till it was reduced to a mealy conſiſtence. He put part of it, with an equal proportion of the boiling liquor, into a cylindrical glaſs veſſel, that held ſomething leſs than half a wine pint, and covered it cloſe immediately with a glaſs cover. At the ſame time he ſliced an unboiled potatoe, and, as near as he could judge, put the ſame quantity into a glaſs veſſel of the ſame kind, with the ſame proportion of New River water not boiled, and covered it with a glaſs cover, and placed both veſſels cloſe to each other.

On the 26th of May, twenty-four hours afterwards, he examined a ſmall drop of each by the firſt magnifier of Wilſon's microſcope, whoſe focal diſtance is reckoned at $\frac{1}{50}$ part of an inch; and, to his amazement, they were both full of animalcula of a linear ſhape, very diſtinguiſhable, moving to and fro with great celerity; ſo that there appeared to be more particles of animal than vegetable life in each drop.

This experiment he repeatedly tried, and always found it to ſucceed in proportion to the heat of the circumambient air; ſo that even in winter, if the liquors are kept properly warm, at leaſt in two or three days the experiment will ſucceed.

The animalcula are infinitely ſmaller than ſpermatic animals, and of a very different ſhape; the truth of which every accurate obſerver will ſoon be convinced of, whoſe curioſity may lead him to compare them, and he is perſuaded they will find they are no way akin.

Having learnt from Mr. De Sauſſure, of Geneva, that he found one kind of theſe animalcula infuſoria that increaſe by dividing acroſs into nearly two equal parts, and that the infuſion was made from hemp-ſeed, he procured a quantity of this ſeed, ſome of it he put into New River water, ſome into diſtilled water, and ſome into very hard pump water; the reſult was, that in proportion to the heat of the weather, or the warmth in which they were kept, there was an appearance of millions of minute animalcula in all the infuſions; and, ſome time after, ſome oval ones made their appearance; theſe were much larger than the firſt, which ſtill continued; theſe wriggled to and fro in an undulatory motion, turning themſelves round very quick all the time that they moved forwards.

Mr. Ellis found out, by mere accident, a method to make their fins appear very diſtinctly, eſpecially in the larger kind of animalcula, which are common to moſt vegetable infuſions, ſuch as the terebella. This has a longiſh body, with a cavity or groove at one end, like a gimlet: by applying a ſmall ſtalk of the horſeſhoe geranium, (or geranium zonale of Linnæus) freſh broken, to a drop of water in which theſe animalcula are ſwimming, we ſhall find that they will become torpid inſtantly, contracting themſelves into an oblong oval ſhape, with their fins extended like ſo many briſtles all round their bodies. The fins are in length about half the diameter of the middle of their bodies. Before he diſcovered this expedient, he tried to kill them by different kinds of ſalts and ſpirits; but though they were deſtroyed by this means, their fins were ſo contracted, that he could not diſtinguiſh them in the leaſt. After lying in this ſtate of torpidity for two or three minutes, if a drop of clean water be applied to them, they will recover their ſhape, and ſwim about immediately, rendering their fins again inviſible.

It is one of the wonders of the modern philoſophy to have invented means for bringing creatures, ſo imperceptible as the various animalcula, under our cognizance and inſpection. One might well have deemed an object that was a thouſand times too little to affect our ſenſe, as perfectly removed from human diſcovery; yet we have extended our ſight over animals to whom theſe would be mountains. In reality, the greater number of microſcopic animalcula are of ſo ſmall a ſize, that through a lens, whoſe focal diſtance is the tenth part of an inch, they only appear as ſo many points; that is, their parts cannot be diſtinguiſhed, ſo that they appear from the vertex of that lens under an angle not exceeding the minute of a degree. If we inveſtigate the magnitude of ſuch an object, it will be found nearly equal to $\frac{3}{100000}$ of an inch long. Suppoſing, therefore, theſe animalcula to be of a cubic figure, that is, of the ſame length, breadth, and thickneſs, their magnitude would be expreſſed by the cube of the fraction $\frac{3}{100000}$, that is, by the number $\frac{27}{1000000000000000}$, that is, each animalculum is equal to ſo many parts of a ſquare inch. This contemplation of animalcula has rendered the idea of indefinitely ſmall bodies very familiar to us; a mite was formerly thought the limit of littleneſs, but we are not now ſurprized to be told of animals many millions of times ſmaller than a mite; for there are ſome animalcula ſo ſmall, that, upon calculation, the whole earth is not found large enough to be a third proportional to theſe little animals, and the whale in the ocean.* Theſe conſiderations are ſtill further heightened, by reflecting on the internal ſtructure of animalcula, for each muſt have all the proportion, ſymmetry, and adjuſtment of that organized texture, which is indiſpenſibly neceſſary for the ſeveral functions of life, and each muſt be furniſhed with proper organs, tubes, &c. for ſecreting the fluids, digeſting it's food, and propagating it's ſpecies.

Having thus given a general idea of the properties of animalcula, we now proceed to deſcribe the various individuals, following the arrangements of O. F. Müller,† and giving the reader the diſcriminating characters by which he has diſtinguiſhed them, abridging, enlarging, or altering the deſcriptions, to render them in ſome inſtances more exact, in others leſs tedious; and upon the whole I hope, more intereſting to the reader.

## A METHODICAL DIVISION OF THE ANIMALCULA INFUSORIA.

### I. Thoſe that have no external organs.

1. Monas: punctiforme. A mere point.

2. Proteus: mutabile. Mutable.

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* Cyclopedia Britannica, Art. Animalcule.

† Müller Animalcula Infuſoria, Fluviatilia et Marina.

3. Volvox: ſphæricum. Spherical.

4. Enchelis: cylindraceum. Cylindrical.

5. Vibrio: elongatum. Long.

* Membranaceous.

6. Cyclidium: ovale. Oval.

7. Paramæcium: oblongum: Oblong.

8. Kolpoda: ſinuatum. Sinuous.

9. Gonium: angulatum. With angles.

10. Burſaria. Hollow like a purſe.

II. Thoſe that have external organs.

* Naked, or not incloſed in a ſhell.

1. Cercaria: caudatum. With a tail.

2. Trichoda: crinitum.

3. Kerona: corniculatum. With horns.

4. Himantopus: cirratum. Cirrated.

5. Leucophra: ciliatum undique. Every part ciliated.

6. Vorticella: ciliatum apice. The apex ciliated.

* Covered with a ſhell.

7. Brachionus: ciliatum apice. The apex ciliated.

## I. MONAS.

Vermis inconſpicuus, ſimpliſſimus, pellucidus, punctiformis. An inviſible,* pellucid, ſimple, punctiform worm.

### 1. Monas Termo.

Monas gelatinoſa. Gelatinous Mona.

Animalcules ſemblable a des points, ſpall. op. phyſ. I. p.
Bullæ continuo motu, Bonanni obſ. p. 174.

Among the various animalcula which are diſcovered by the microſcope, this is the moſt minute, and the moſt ſimple; a ſmall jelly-like point, eluding the powers of the compound microſcope, and being but imperfectly ſeen by the ſingle; theſe, and ſome others of the mona kind, are ſo delicate and ſlender, that it is no wonder they often eſcape the ſight of many who have examined infuſions with attention; in a full light they totally diſappear, their thin and tranſparent forms blending as it were with the water in which they ſwim.

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* By inviſible we only mean that they are too ſmall to be diſcerned by the naked eye.

Small drops of infuſed water are often ſo full of theſe, that it is not eaſy to diſcover the leaſt empty ſpace, ſo that the water itſelf ſeems changed into another ſubſtance leſs tranſparent, but conſiſting of an innumerable number of globular points, thick ſown together. In this a motion may be perceived, ſomething ſimilar to that which is obſerved when the ſun's rays ſhine on the water, the animalcula being violently agitated, or in a commotion like unto a hive of bees. It is very common in ditch water, and in almoſt all infuſions, both of animal and vegetable ſubſtances.

### 2. Monas Atomus.

Monas albida puncto, variabili inſtructa, Plate XXV. Fig. 1. White mona, with a variable point.

This animalculum appears as a white point, which, when it is highly magnified, is ſomewhat of an egg ſhape; the ſmaller end is generally marked with a black point, the ſituation of this is ſometimes varied, and found at the other end of the animalculum; ſometimes two black points are to be ſeen croſſing the middle of the body.

It was found in ſea water that had been kept the whole winter; it was not, however, very fœtid; there were no other animalcula in the ſame water.

### 3. Monas Punctum.

Monas nigra. A black mona.

A very minute point, ſolid, opake and black, round and long. They are diſperſed in the infuſion, and move with a ſlow wavering motion; were found in a fœtid infuſion of pears.

### 4. Monas Ocellus.

Monas hyalina puncto centrali notata. Tranſparent like talc, with a point in the middle.

The margin black, and a black point in the middle; it moves irregularly, is found in ditches covered with conferva, and frequently with the cyclidium milium.

### 5. Monas Lens.

Monas hyalina. Tranſparent mona, of a talcy appearance.

This is among the number of the ſmaller animalcula, nearly of a round figure, and ſo pellucid, that it is not poſſible to diſcover the leaſt veſtige of inteſtines. Though they may often be ſeen ſeparate, yet they are more generally collected together, forming a kind of veſicular or membranaceous maſs. Contrary to the cuſtom of other animalcula, they ſeek the edges of the evaporating water, the conſequence of which is almoſt immediate death. When the water is nearly evaporated, a few dark ſhades are perceived, probably occaſioned by the wrinkling of the body.

A ſlow tremulous motion, confined to one ſpot, may be perceived at intervals; this in a little time becomes more lively, and ſoon pervades the whole drop.

It's motions are, in general, very quick; two united together may ſometimes be ſeen ſwimming among the reſt; while in this ſituation they have been miſtaken by ſome writers for a different ſpecies, whereas it is the ſame generating another by diviſion.

It is to be found in all water, though but ſeldom in that which is pure; they are in great plenty in the ſummer in ditch water, alſo in infuſions of animal or vegetable ſubſtances, made either of freſh or ſalt water, myriads being contained in a drop; numbers, of various ſizes, are to be found in the filth of the teeth.

The animalcula of this and the firſt ſpecies are ſo numerous as to exceed all calculation, though they are contained in a very confined ſpace.

### 6. Monas Mica.

Monas, circulo notata. Mona, marked with a circle.

This lucid little point may be diſcovered with the third lens of the common ſingle microſcope, when the magnifying power is increaſed; it appears either of an oval or ſpherical figure, for it aſſumes either at pleaſure. It is tranſparent, and has a ſmall ellipſe inſcribed as it were within it's circumference; this ellipſe is moveable, being ſometimes in the middle, ſometimes a little towards the fore-part, at others nearer the hind-part.

There is a conſiderable variety in it's motions; it often turns round for a long time in the ſame place; an appearance like two kidneys may ſometimes be perceived in the middle of the body, and the animalculum is beautifully encompaſſed with a kind of halo, ariſing, moſt probably, from inviſible and vibrating hairs.

They are to be found in the pureſt waters.

### 7. Monas Tranquilla.

Monas ovata, hyalina, margine nigro. Egg-ſhaped, tranſparent mona, with a black margin.

Theſe animated points ſeem to be nearly fixed to one ſpot, where they have a vacillatory motion. They are frequently ſurrounded with a halo, and differ in their figure, being ſometimes rather ſpherical, at others quadrangular. The black margin is not always to be found, and ſometimes one would almoſt be tempted to think it had a tail. It is found in urine which has been kept for a time. The urine is covered, after it has remained in the veſſel, with a dark-coloured pellicule, in which theſe animals live: although the urine was preſerved for ſeveral months, no new animalcula were obſerved therein. It has been already ſhewn, that a drop of urine is in general fatal to other animalcula, yet we find that it has animated beings of a peculiar kind, appropriated to, and living in it.

### 8. Monas Lamellula.

Monas, hyalina compreſſa. Flat tranſparent monas.

This is moſtly found in ſalt water. It is of a whitiſh colour, more than twice as long as it is broad, tranſparent, with a dark margin, the motion vacillatory ; it often appears as if double.

### 9. Monas Pulviſculus.

Monas hyalina, margini virente. Tranſparent mona, with a green margin.

Little ſpherical pellucid grains, of different ſizes, the circumference green, a green bent line paſſes through the middle of ſome, probably indicating that they are near ſeparating, or dividing, into two diſtinct animalculum ; ſometimes three or four, at others ſix and ſeven, or even more, are collected together. They rove about with a wavering motion, and are moſtly found in the month of March in marſhy grounds.

### 10. Monas Uva.

Monas hyalina gregaria. Tranſparent gregarious monas.

It is not eaſy to decide on the nature of theſe little aſſemblages of corpuſcles, which ſometimes conſiſt of five, at other times of four, and frequently of many more ; the corpuſcles are of different ſizes, according to the number collected in one group. When collected in a heap, the only motion they have is a kind of revolution, or rolling round. The ſmaller particles ſeparate from the larger, often dividing into as many portions as there are conſtituent particles in the group; when ſeparated, they move about with incredible ſwiftneſs.

To try whether this was a group of animalcula collected together by chance, or whether it was their natural ſtate to be thus grouped together, the following experiment was made. A ſingle corpuſcle was taken the moment it was ſeparated from the heap, and placed in a glaſs by itſelf; it ſoon increaſed in ſize, and when it had attained nearly the ſame bulk as the group from which it was ſeparated, the ſurface began to aſſume a wrinkled appearance, which gradually changed till it became exactly ſimilar to the parent group. This new-formed group was again decompoſed, like the preceding one, and in a little time the ſeparated particles became as large as that from which they proceeded.

It is found in a variety of infuſions.

## II. PROTEUS.

Vermis inconſpicuus, ſimpliciſſimus, pellucidus, mutabilis. An inviſible, very ſimple, pellucid worm, of a variable form.

### 11. Proteus Diffluens.

Proteus in ramulos diffluens, Fig. 2 and 3, Plate XXV. Proteus, branching itſelf out in a variety of directions.

A very ſingular animalculum, appearing only as a grey mucous maſs; it is filled with a number of black globules, of different ſizes, and is continually changing it's figure. Being formed of a gelatinous pellucid ſubſtance, the ſhape is eaſily altered, and it puſhes out branches of different lengths and breadths. The globules which are within divide and paſs immediately into the new-formed parts, always following the various changes of form in the animalcula. The changes that are obſerved in the form of this little creature, do not ariſe from any extraneous cauſe, but are entirely dependent on it's internal powers.

It is to be met with but very ſeldom; the indefatigable Muller only ſaw it twice, although he examined ſuch an immenſe variety of infuſions.

It is to be found in fenny ſituations.

### 12. Proteus Tenax.

Proteus in ſpiculum diffluens, Fig. 4 and 5, Plate XXV. Proteus, running out into a fine point.

A gelatinous pellucid body, ſtored with black molecules; it changes it's form like the preceding, but always in a regular order, firſt extending itſelf out in a ſtrait line, the lower part terminating in an acute bright point, without any inteſtines, and the globules being all collected in the upper part, it next draws the pointed end up towards the middle of the body, ſwelling it into a round form. The contraction goes on for ſome time, after which the lower part is ſwelled out as it is repreſented in Fig. 4; the point is afterwards projected from this ventricoſe part. It paſſes through five different forms before it arrives at that which is ſeen at Fig. 4. It ſcarcely moves from one ſpot, only bending about ſideways. It is to be found in river water, where the C nitida grows,—a the tail, c the head, d the protuberant ſwelling.

## III. VOLVOX.

Volvox inconſpicuus ſimpliciſſimus, pellucidus, ſphæricus. An inviſible, very ſimple, pellucid, ſphærical worm.

### 13. Volvox Punctum.

Volvox ſphæricus, nigricans, puncto lucido. Spherical, of a black colour, with a lucid point.

A ſmall globule; one hemiſphere is opake and black, the other has a pellucid cryſtalline appearance; a vehement motion is obſervable in the dark part. It moves in a tremulous manner, and often paſſes through the drop, turning round as if upon an axis. Many may be often ſeen joined together in their paſſage through the water, they ſometimes move as in a little whirlpool, and then ſeparate. It is found in great numbers on the ſurface of fœtid ſea water.

### 14. Volvox Granulum.

Volvox ſphæricus, viridis, peripheria hyalina. Sphærical and green, the circumference of a bright colour.

There ſeems to be a kind of green opake nucleus in this animalculum; the circumference is tranſparent. It is to be found generally in the month of June, in marſhy places; it moves but ſlowly.

### 15. Volvox Globulus.

Volvox globoſus, poſtice ſubobſcurus. Globular volvox, the hinder part ſomewhat obſcure.

This globular animalculum is ten times larger than the mona lens; it verges ſometimes a little towards the oval in it's form. The inteſtines are juſt viſible, and make the hinder part of the body appear opake; it has commonly a ſlow fluttering kind of motion, but if it is diſturbed the motion is more rapid.

It is found in moſt infuſions of vegetables.

### 16. Volvox Pilula.

Volvox ſphæricus, interaneis immobilibus vireſcentibus. Small round volvox, with immoveable green inteſtines:

This is a ſmall tranſparent animalculum; it's inteſtines are immoveable, of a green colour, and are placed near the middle of the body the edges often yellow ; a ſmall obtuſe inciſion may be diſcovered on the edge, which is, perhaps, the mouth of the animalculum. This little creature appears to be encompaſſed with a kind of halo, or circle. If this is occaſioned by the vibratory motion of any fringe of hairs, they are inviſible to the eye, even when aſſiſted by the microſcope.

It ſeems to have a kind of rotatory motion, at one time ſlow, at another quick, and is to be found in water where the lemna minor grows, ſometimes as late as the month of December.

### 17. Volvox Grandinella.

Volvox ſphæricus, opacus, interaneis immobilibus. Spherical and opake, with immoveable inteſtines.

This is much ſmaller than the preceding, and is marked with ſeveral circular lines ; no motion is to be perceived among the interior molecules. It ſometimes moves about in a ſtrait line, ſometimes it's courſe is irregular, at others it keeps in the ſame ſpot, with a tremulous motion.

### 18. Volvox Socialis.

Volvox ſphæricus, moleculis cryſtallinis, æqualibus diſtantibus. Spherical volvox, with cryſtalline molecules, placed at equal diſtances from one another.

When very much magnified, this animalculum ſeems to have ſome relation to the vorticella ſocialis, as ſeen with the naked eye. It conſiſts of cryſtalline molecules, diſpoſed in a ſphere, and filling up the whole circumference; they are all of an equal ſize. Whether they are included in a common membrane, or whether they are united by one common ſtalk, as in the vorticella ſocialis, has not been diſcovered. We are alſo ignorant of the exact figure of the little particles of which it is compoſed; when a very large magnifying power is uſed, ſome black points may be diſcerned in the center of the cryſtalline molecules. The motion is ſometimes rotatory, ſometimes from right to left, and the contrary. It is found where the chara vulgaris has been kept.

### 19. Volvox Sphæricula.

Volvox ſphæricus, moleculis ſimilaribus rotundis. Spherical volvox, with round molecules.

This ſpherule is formed of pellucid homogeneous points, of different ſizes. It moves ſlowly about a quarter of a circle from right to left, and then back again from left to right.

### 20. Volvox Lunula.

Volvox hemiſphæricus, moleculis ſimilaribus lunatis. An hemiſpherical volvox, with lunular molecules. Fig. 7, Plate XXV.

Is a ſmall roundiſh tranſparent body, compoſed of innumerable molecules, homogeneous, pellucid, and of the ſhape of the moon in it's firſt quarter, without any common margin.

It is in a continual twofold motion; the one of the whole maſs turning ſlowly round, the other of the molecules one among the other. They are found in marſhy places in the beginning of ſpring.

## 21. Volvox Globator.

Volvox ſphæricus membranaceus. Spherical membranaceous volvox.

This is a tranſparent globule, of a greeniſh colour; the fœtus is compoſed of ſmaller greeniſh globules. It becomes whiter and brighter with age, moves ſlowly round it's axis, and may be perceived by the naked eye.

But to the microſcope the ſuperficies of this pellucid membrane appears covered with molecules, as if it were granulated, which has occaſioned ſome obſervers to imagine it to be hairy; the round pellucid molecules that are fixed in the center are generally largeſt in thoſe that are young. The exterior molecules may be wiped off, leaving the membrane naked.

When the young ones are of a proper ſize, the membrane opens, and they paſs through the fiſſure; after this, the mother melts away. They ſometimes change their ſpherical figure, the ſuperficies being flattened in different places.

Moſt authors ſpeak of finding eight leſſer globules within the larger; but Muller ſays, that he has counted thirty or forty of different ſizes. This wonderful incapſulation of it's progeny is well known; indeed it often exhibits itſelf big with children and grandchildren.

Leeuwenhoeck was the firſt who noticed this curious animalculum, and depicted it; a circumſtance which has not been mentioned by Baker and other microſcopic writers who have deſcribed it. It may be found in great plenty in ſtagnant waters in ſpring and ſummer, and in infuſions of hemp-ſeed and tremella.

It is thus deſcribed by Mr. Baker. This ſingular minute water animal, ſeen before the microſcope, appears to be exactly globular, without either head, tail, or fins. It moves in all directions, forwards or backwards, up or down, rolling over and over like a bowl, ſpinning horizontally like a top, or gliding along ſmoothly without turning itſelf at all. Sometimes it's motions are very ſlow, at other times very ſwift; and when it pleaſes it can turn round as upon an axis very nimble, without moving out of it's place. The body is tranſparent, except where the circular ſpots are placed, which are probably it's young. The ſurface of the body in ſome is as it were dotted all over with little points, and in others as if granulated like ſhagreen. Mr. Baker thought alſo that in general it appeared as if it was ſet round with ſhort moveable hairs.

By another writer they are thus deſcribed. Theſe animalcula are at firſt very ſmall, but grow ſo large as to be diſcerned with the naked eye; they are of a yellowiſh green colour, globular figure, and in ſubſtance membranaceous and tranſparent; in the midſt of this ſubſtance ſeveral ſmall globes may be perceived; each of theſe are ſmaller animalcula, which have alſo their diaphanous membrane, and contain within themſelves ſtill ſmaller generations, which may be diſtinguiſhed by the aſſiſtance of very powerful glaſſes. The larger globules may be ſeen to eſcape from the parent, and then increaſe in ſize, as we have already obſerved.

## 22. Volvox Morum.

Volvox membranaceus orbicularis, centro moleculis ſphæricis viridibus. Membranaceous orbicular, with ſpherical green molecules in the center.

This animalculum has ſome reſemblance to the volvox uva, but is ſufficiently diſtinguiſhed by the ſurrounding bright orbicular membrane. The middle part is full of clear green globules. The globules ſeldom move, though a quivering motion may ſometimes be perceived at the center. It has a ſlow rotatory motion, and is found amongſt the lemna, in the months of October and December.

## 23. Volvox Uva.

Volvox globoſus, moleculis ſphæricis vireſcentibus nudis. Globular volvox, compoſed of green ſpherical globules, which are not incloſed in a common membrane.

This animalculum ſeems to be a kind of medium between the volvox pillula and the gonium pectorale, being like the one compoſed of green ſpherules, and in form reſembling the other.

It conſiſts of a congeries of equal globules of a greeniſh colour, with a bright ſpot in the middle; the whole maſs is ſometimes of a ſpherical form, ſometimes oval, without any common membrane; a kind of halo may be perceived round it, but whether this is occaſioned by the motion of any inviſible hairs has not been diſcovered. The maſs generally moves from right to left, and from left to right; ſcarce any motion can be diſcovered in the globules themſelves. It was found in the month of Auguſt, in water where the lemna polyrrhiza was growing. Two maſſes of theſe globules have been ſeen joined together. They contain from four to fifty of the globules, of which a ſolitary one may now and then be found.

### 24. Volvox Vegetans.

Volvox ramulis ſimplicibus & dichitomis, roſula globulari terminatis. A volvox with ſimple dichitomous branches, terminating in a little bunch of globules.

It conſiſts of a number of floccoſe opake branches, which are inviſible to the naked eye; at the apex of theſe there is a little congeries of very minute oval pellucid corpuſcles. Muller at firſt thought it to be a ſpecies of microſcopic and river ſertularia; but afterwards he found the bunches quitting the branches, and ſwimming about in the water with a proper ſpontaneous motion. Many old branches were found deſerted of their globules, while the younger branches were furniſhed with them. It was found in river water in November 1779 and 1780.

## IV. ENCHELIS.

Vermis inconſpicuus, ſimpliciſſimus, cylindraceus. An inviſible, ſimple, cylindric worm.

### 25. Enchelis Viridis.

Enchelis ſubcylindrica, antice oblique truncata. Green enchelis, of a ſubcylindric figure, the fore-part truncated.

This is an opake, green, ſubcylindric animalculum, with an obtuſe tail, the fore-part terminating in an acute truncated angle; the inteſtines obſcure and indiſtinct.

It is continually varying in it's motion, turning from right to left.

### 26. Enchelis Punctifera.

Enchelis viridis, ſubcylindracea, antice obtuſa, poſtice acuminata, Fig. 8, Plate XXV. Green enchelis, ſubcylindric, the fore-part obtuſe, the hinder-part pointed.

It is an opake animalculum, of a green colour; there is a ſmall pellucid ſpot in the fore-part a, in which two black points may be ſeen; a kind of double band, c c, croſſes the middle of the body. The hinder part is pellucid and pointed; an inciſion is diſcoverable at the apex of the fore-part, which ſeems to be the mouth. When in motion, the whole of it appears opake and green. Is found in marſhes.

### 27. Enchelis Deſes.

Enchelis viridis, cylindrica, ſubacuminata gelatinoſa. Green, cylindrical, gelatinous, the ends ſomewhat pointed.

The body is round, the colour a very dark green, ſo that it is quite opake; the fore-part is bluntly rounded off, the hinder part is ſomewhat tapering, but finiſhes with a rounded end. From it's opacity, no internal parts can be diſcovered; there is a degree of tranſparency near the ends.

It is exceeding idle, moving very ſlowly; to be found, though rarely, in an infuſion of lemnæ.

### 28. Enchelis Similis.

Enchelis obovato-opaca, interaneis mobilibus. Enchelis of an egg-ſhape, opake, with moveable inteſtines.

It is an opake body, with a pellucid margin; both extremities are obtuſe, but the upper one much more ſo than the under one; it is filled with moveable ſpherules. It's motion is generally quick, either to the right or the left; it is probably furniſhed with hairs, becauſe, when moving rapidly, the margin appears ſtriated. It is found in water that has been kept for months.

### 29. Enchelis Serotina.

Enchelis ovato-cylindracea, interaneis immobilibus. Enchelis partly oval, partly cylindrical, the interior parts immoveable.

An oval animalculum, round, the fore-part ſmaller than the hind-part, the margin of a black colour; it is replete with grey veſicular molecules, and moves ſlowly.

### 30. Enchelis Nebuloſa.

Enchelis ovato-cylindracea, interaneis manifeſtis mobilibus. Oval and cylindric enchelis, with viſible moveable inteſtines.

The body is ſhaped like an egg, the fore-part narrow, and often filled with opake confuſed inteſtines; in moving, it elevates the fore-part of the body. It is found in the ſame water as the cyclidium glaucoma, but is three times larger, and an hundred times more ſcarce.

### 31. Enchelis Seminulum.

Enchelis cylindracea æqualis. Enchelis equally cylindric.

It is a cylindrical animalculum, twice as long as it is broad, the fore and hind-part of the ſame ſize; the inteſtines in the fore-part are pellucid, thoſe in the hinder-part obſcure. It moves by aſcending and deſcending alternately. It may be ſeen ſometimes ſwimming about with the extremities joined together. Found in water that has been kept for ſome days.

### 32. Enchelis Intermedia.

Enchelis cylindracea, hyalina, margine nigricante. Cylindrical enchelis, tranſparent, with a blackiſh margin.

This animalculum forms an intermediate kind between the monas punctum, the enchelis ſeminulum, and the cyclidium milium. It is one of the ſmalleſt among the animalcula. The body is tranſparent, it has no viſible inteſtines, the fore and hind-part are of an equal ſize, the edge of a deeper colour than the reſt of the body; a point is to be ſeen in the middle of ſome of them, in others it is as if a line paſſed through the middle.

### 33. Enchelis Ovulum.

Enchelis cylindrico-ovata hyalina. Egg-ſhaped tranſparent enchelis.

A tranſparent, round, egg-ſhaped animalculum; nothing is diſcovered within ſide, even by the third magnifier; but with an increaſed power ſome long foldings may be ſeen on the ſuperficies, and here and there a few bright molecules.

### 34. Enchelis Pirum.

Enchelis inverſe conica, poſtice hyalina. Pear-form enchelis, the hinder-part tranſparent.

This enchelis is lively and pellucid, the fore-part is protuberant, and filled with molecules, the hinder-part ſmaller and empty; it has moveable molecular inteſtines. It's motion is rapid, paſſing backwards and forwards through the diameter of the drop. When at reſt, it ſeems to have a little ſwelling, or tubercle, on the middle of the body.

### 35. Enchelis Tremula.

Enchelis ovato-cylindracea, gelatina. Oval enchelis, cylindrical, gelatinous.

This is alſo to be placed amongſt the moſt minute animalcula; the end of it is rather pointed, and has a tremulous motion; it almoſt induces one to think it has a tail. Two of theſe little creatures may at times be perceived to adhere together. It was found in an infuſion with the paramæcia aurelia, and many other animalcula.

### 36. Enchelis Conſtricta.

Enchelis obovata, cryſtallina, medio coarctata. Suboval enchelis, cryſtalline, with a ſtricture in the middle.

An animalculum of an oval ſhape, the middle part drawn in, as if a ſtring was tied round it. It is of a very ſmall ſize, and is found in ſalt water.

### 37. Enchelis Pulviſculus.

Enchelis eliptica, interaneorum congerie viridi. Of an eliptic ſhape, with a congeries of green inteſtines.

It is a round animalculum, pellucid, the fore-part obtuſe, the hind-part rather ſharp, marked with green ſpots; myriads may ſometimes be ſeen wandering about in one drop; it is found among the green matter on the ſides of the veſſels in which water has been kept for ſome time.

### 38. Enchelis Fuſus.

Enchelis cylindracea, utraque extremitate anguſtiore truncata. Cylindrical enchelis, both ends truncated.

The body is round and tranſparent, the fore and hind-part ſmaller than the reſt of the body, and equally ſo, the ends a little truncated. In the inſide a long and ſomewhat winding inteſtine, a ſky-coloured bright fluid, and ſome black molecules tranſverſely ſituated, may be diſcerned.

It's motions are languid; was found in pure water.

### 39. Enchelis Fritillus.

A cylindric enchelis, the fore-part truncated.

This is one of the moſt tranſparent animalcula; the hinder-part of an obtuſe convexity, the fore-part truncated. Muller ſuſpects that there is a rotatory organ in the fore-part. No inteſtines can be ſeen. It runs backwards and forwards through the drop in a diametrical line, with a wavering motion; ſometimes turns round for a moment, but preſently enters on it's uſual courſe. Is found in an infuſion of graſs and hay.

### 40. Enchelis Caudata.

Enchelis elongata, antice obtuſa, poſtice in caudam hyalinam attenuata, Fig. 9, Plate XXV. Enchelis with a long body, the fore-part obtuſe, the hinder-part diminiſhing into a kind of tail.

The body is of a grey colour, pellucid, with globular molecules divided from each other, and diſperſed through the whole body; the fore-part, a, thick and obtuſe, the hind-part, b, cryſtalline and ſmall, the end truncated. It is but ſeldom met with.

### 41. Enchelis Epiſtomium.

Enchelis cylindrico-elongata, apice gracili ſubgloboſo. Enchelis with a long cylindric body, the fore-part ſlender and roundiſh.

It is among the ſmaller animalcula; the body is cylindrical and bright, the hind-part obtuſe, the fore-part ſmaller, and terminating in a globule; a black line may now and then be perceived down the middle of it.

### 42. Enchelis Gemmata.

Enchelis cylindracea, ſerie globulorum duplici, in collum hyalinum producta. Enchelis with a cylindrical body, the upper part prolonged into a tranſparent neck, a double ſeries of globules running down the body. It's motion is ſlow, and generally in a ſtrait line; it is found in ditch-water where the lemna thrives.

### 43. Enchelis Retrograda.

Enchelis hyalina, antice anguſtata, apice globulari. Tranſparent enchelis, the fore-part rather ſmaller, and terminating in a ſmall globule, Fig. 11 and 12, Plate XXV.

It has a gelatinous tranſparent body; no viſible inteſtines, though a pellucid globule is diſcoverable near the hinder part; the body is thickeſt in the middle, and grows ſmaller towards each end. It generally moves ſide-ways, ſometimes in a retrograde manner; and if it is obſtructed in it's motion, draws itſelf up as it is repreſented at Fig. 11.

### 44. Enchelis Feſtinans.

Enchelis cylindrica oblonga, obtuſa, antice hyalina. Oblong cylindrical enchelis; the ends obtuſe, the fore-part tranſparent.

The body is round, of an equal ſize throughout, and both ends obtuſe; more than half the length is without any viſible inteſtines, the lower end full of veſicular, pellucid, minute globules; a large globular veſicle is alſo to be found in the fore-part; it moves quickly from one ſide to the other, in a vacillatory manner. It was found in ſea-water.

### 45. Enchelis Farcimen.

Enchelis cylindracea curvata utrinque truncata. A cylindric enchelis, crooked and truncated at both ends.

The body of this is cylindrical, about four times longer than it is wide, even, truncated at both ends, the inteſtines opake, and not to be diſtinguiſhed; it turns the extremities oppoſite ways, ſo as to form the figure of an S. It is to be found in water that has ſtood for ſome time, though but ſeldom. Joblot found it in an infuſion of blue bottles; it moves in an undulatory manner, but very ſlowly.

### 46. Enchelis Index.

Enchelis inverſe conica, apicis altero angulo producto. Enchelis in the form of an inverted cone, one edge of the apex produced out ſo as to form an angle with the other part.

The body rather opake, of a grey colour, and of a long conical figure; the lower end obtuſe, the fore-part thick, one ſide of this part projecting like a finger from the edge; two very ſmall projections proceed alſo ſometimes from the lower end.

This animalculum has the power of retracting theſe projections, and making both ends appear obtuſe. It moves about but ſlowly, and was found in water with the lemna minor.

### 47. Enchelis Truncus.

Enchelis cylindrica, ſubcapitata. Fig. 10. Plate XXV. Cylindrical enchelis with a kind of head.

This is the largeſt of this kind of animalcula; the body is cylindrical, mucoſe, grey, long and rather opake, the fore-part globular, the hind-part obtuſe. Something like three teeth (c) may be ſometimes ſeen to proceed from one of the ſides; it can alter it's ſhape conſiderably. Globules of different ſizes may be ſeen within the body. It rolls about ſlowly from right to left.

### 48. Enchelis Larva.

Enchelis elongata, medio papillula utrinque notata. A long enchelis, with two little nipples projecting from the middle of the body, one on each ſide.

It is long, round, and filled with grey molecules; the fore-part is obtuſe and pellucid; a kind of neck, or ſmall contraction, is formed at ſome little diſtance from this end. The lower part pointed, about the middle of the body there are two ſmall projections.

## 49. Enchelis Spatula.

Enchelis cylindrica ſtriata, apice hyalino-ſpatulata. A cylindrical ſtriated enchelis, the fore-part tranſparent, and of the ſhape of a ſpatula.

This animalculum is perfectly cylindrical, very pellucid, of a cryſtalline appearance; it is marked with very fine longitudinal furrows, and has generally two tranſparent globules, one placed below the middle, the other near the extremity of the body; on the other ſide are five ſmaller ones, which are oval. The top is dilated, with the corners rounded like the ſpatula of the apothecaries. It has a wavering kind of motion, folding the ſpatula variouſly, yet retaining the form in general. Muller mentions his ſeeing it once draw the ſpatula into the body, and keep it there for two hours, when it again appeared.

## 50. Enchelis Pupula.

A cylindric enchelis, the fore-part papillary.

The fore-part is protuberantly round, and rather opake, the hind-part pellucid, both extremities obtuſe, furniſhed with a papillary finger-ſhaped head, the hinder-part marked with a tranſparent circle, or circular aperture. The fore-part filled up with moveable molecules, which are more ſcarce in the hinder-part. It has a rotatory motion on a longitudinal axis, and moves through the water in an oblique direction. It is to be found in dunghill water in November and December.

### 51. Enchelis Pupa.

Enchelis ventricoſo-cylindrica, apice in papillam producta. Enchelis forming a kind of ventricoſe cylinder, with a ſmall nipple proceeding from the apex.

It is not unlike the preceding animalculum, but is much larger; the anterior end not ſo obtuſe, the nipple gradually formed from the fore-part, all but this end is opake, and filled with obſcure particles: it has no tranſparent circle, as was obſerved in the enchelis pupula. It is exceeding ſlothful.

## V. VIBRIO.

Vermis inconſpicuus, ſimpliciſſimus, teres, elongatus. An inviſible worm, very ſimple, round, and rather long.

### 52. Vibrio Lineola.

Vibrio linearis minutiſſimus. Very ſmall linear vibrio.

This is one of the moſt minute animalcula, ſurpaſſing in ſlenderneſs the monas termo. The greateſt magnifier exhibits little more than a tremulous motion of myriads of little oblong obſcure points. In a few days it almoſt fills the whole ſubſtance of the water in vegetable infuſions.

## 53. Vibrio Rugula.

Vibrio linearis flexuoſus. Vibrio like a bent line.

Myriads of this ſpecies may be found; it is between the vibrio lineola and the vibrio undula.

It appears as a little line, which is ſometimes drawn up in an undulated ſhape, and moves backwards and forwards in a ſtrait line, often without bending the body at all.

## 54. Vibrio Bacillus.

Vibrio linearis, æqualis utrinque truncata. Linear vibrio, equally truncated at both ends.

This is an exceeding ſmall creature, but viſible with the third lens; in a certain poſition of the light tranſparent. It is gelatinous, and not half ſo large as the monas lens, though ſix, and ſometimes ten times longer; it is every-where of an equal ſize, and has no viſible inteſtines; it's action is languid, the ſerpentine flexures of the body are with great difficulty perceived.

Muller made two infuſions of hay in the ſame water, and at the ſame time in the one he put the hay whole, in the other it was cut in ſmall pieces; in the firſt there was none of the vibrio bacillus, but many of the monas lens and kolpoda cucullus; in the latter, many of vibrio bacillus, and few of the monæ.

## 55. Vibrio Undula.

Vibrio filiformis flexuoſus. A filiform flexuous vibrio.

A perfect undulating little line, round, gelatinous, without any viſible inteſtines. It is never ſtrait; when at reſt it reſembles the letter V, when in motion the letter M, or a bending line like that which geeſe form in their flight through the air; it's motions are ſo rapid, that the eye can ſcarce follow them. It generally reſts upon the top of the water, ſometimes it fixes itſelf obliquely by one extremity, and whirls itſelf round.

This is the little creature that Leeuwenhoeck ſays exceeds in ſlenderneſs the tail of the animalculum ſeminale, which he has deſcribed in Fig. 5, Epiſ. Phyſ. 41, being an hundred times leſs than a muſtard-ſeed, and on which he makes the following very juſt obſervation: That as theſe very ſmall animalcula can contract and variouſly fold their little tails, we muſt conclude that tendons and muſcles are as neceſſary to them as to other animals; if to this we add the organs of ſenſation, and thoſe of the inteſtines, the mind is loſt in the aſtoniſhment which ariſes from the impreſſion of infinite, in the indefinitely ſmall.

## 56. Vibrio Serpens.

Vibrio filiformis, ambagibus in angulum obtuſum productis. A filiform vibrio, the windings or flexures obtuſe.

A ſlender gelatinous little animal, in the form of a long ſerpentine line, all the bendings being nearly equal in ſize, and at equal diſtances; it generally moves in a ſtrait line; an inteſtine may be diſcovered down the middle. It is to be found in river water, but is not commonly to be met with.

### 57. Vibrio Spirillum.

Vibrio filiformis, ambagibus in angulum acutum tornatis. Filiform vibrio, twiſted ſomething like a ſpiral wire, or corkſcrew; the bending acute.

It is an exceeding minute ſingular little creature, twiſted in a ſpiral form; the ſhape of theſe bendings remains the ſame even when the animal is in motion, not occaſioned by any internal force, but are it's natural ſhape. It moves generally in a ſtrait line, vibrating the hind and fore-part. It was found in 1782, in an infuſion of the ſonchi arvenſis.

### 58. Vibrio Vermiculus.

Vibrio tortuoſus gelatinus. This little vibrio is twiſted and gelatinous.

The body is white, or rather of a milky appearance, cylindric, long, the apex obtuſe, rather growing ſmaller, and twiſted towards the hind-part. It's motion is languid and undulatory, like that of the common worm; it ſometimes moves quicker, but with ſeeming labour. When it bends itſelf alternately from one ſide to the other, a black long line may be diſcovered, ſometimes whole, ſometimes broken: when at reſt, it occaſionally twiſts into various folds.

It may be obſerved eaſily with the firſt lens of the ſingle microſcope, and is probably the ſame animalculum mentioned by Leeuwenhoeck in all his works, as found in the dung of frogs, and in the ſpawn of the male libellula. It is to be found in marſhy water in November, though but ſeldom.

### 59. Vibrio Inteſtinum.

Vibrio gelatinoſus, teres, antice anguſtatus. This vibrio is gelatinous, round, the fore-part ſmall.

It is cylindric, milk-coloured, and ſlender towards the top, both ends obtuſe; no traces of inteſtines to be diſcovered, though four or five ſpherical eggs are perceived at the extremity of the hind-part. It can draw the fore-part ſo much inwards as to give it a truncated and dilated appearance, ſomething like a ſpatula. It's motion is ſlow and progreſſive. They are found in marſhy waters.

### 60. Vibrio Bipunctatus.

Vibrio linearis, æqualis, utraque extremitate truncata, globulis binis mediis. Linear vibrio, of an equal ſize throughout, both ends truncated, and two ſmall globules in the middle of the body.

It is of a ſmall ſize, and rather leſs than the following animalculum, the body of a pellucid talc-like appearance, the fore and hind-part truncated; in the middle are two (ſometimes there is only one) pellucid globules, placed lengthways. It moſt commonly moves forwards in a ſtrait line; it's movements are ſlow. It was found in ſtinking ſalt water.

## 61. Vibrio Tripunctatus.

Vibrio linearis, utrinque attenuatus, globulis tribus, extremis minoribus. Linear vibrio, both the ends ſmaller than the middle, furniſhed with three globular points, the two which are at the extremities being ſmaller than that at the middle.

The body is pellucid, talcy, each of the ends rather tapering, furniſhed with three pellucid globules, the middle one is the largeſt, the ſpace between theſe globules is generally filled with a green matter; in ſome there is nothing of the green ſubſtance near the extremities, but only about the middle. It ſeldom moves far, and then it's motion is rectilinear, backwards and forwards.

## 62. Vibrio Paxilifer.

Vibrio flaveſcens paleis gregariis multifariam ordinatis, Fig. 13, 14, 15, Plate XXV. Yellow, gregarious, ſtraw-like vibrio.

This is a wonderful animalculum, or rather a congeries of animalcula. It is inviſible to the naked eye, and conſiſts of a tranſparent membrane, with yellow inteſtines, and two or three viſible points; they are generally found collected together in different parcels, from ſeven to forty in number, and ranged in a variety of forms, ſometimes in a ſtrait line, as in Fig. 14, then forming the concave Figure 13, at others moving in a zig-zag direction, as in Fig. 15; when at reſt, they are generally in a quadrangular form, and found in great plenty with the ulva latiſſima.

As this animalculum ſeems to have ſome affinity with the hair-like animal of Mr. Baker, I think the reader will be better pleaſed to ſee his deſcription of it introduced in this place, than to have it raiſed into a new and diſtinct ſpecies.

This little animal is extremely ſlender, and not uncommonly one hundred and fifty times longer than broad. It's reſemblance to an hair induced Mr. Baker to call it the hair-like inſect. The body, or middle part, which is nearly ſtrait, appears in ſome compoſed of ſuch parallel rings as the windpipe of land animals conſiſts of, but ſeems in others ſcaled, or rather made up of rings that obliquely croſs each other. It's two ends are bent, or hooked, pretty nearly in the ſame degree, but in a direction contrary each to the other; and as no eyes can be diſcerned, it is difficult to judge which is the head or tail.

It's progreſſive motion differs from that of all animals hitherto deſcribed, for notwithſtanding the body is compoſed of many rings and joints, it ſeems unable to bend them, or move directly forwards; but when it is inclinable to change it's quarters, it can move from right to left, or left to right, and proceed at the ſame time backwards or forwards obliquely; and this it performs by turning upon one end as a center, and deſcribing with the other the quarter of a circle, then it does the ſame with the other end, and ſo alternately, whereby it's progreſſion is in a diagonal line, or from corner to corner; as whoever will take the trouble to ſhift the points of a pair of compaſſes in that manner, may immediately be ſatisfied.

All it's motions are extremely ſlow, and require much patience and attention in the obſerver. It has neither feet, nor fins, nor hairs, but appears perfectly ſmooth and tranſparent, with the head bending one way, and the tail another, ſo as to be like a long Italic *S*; nor is any internal motion, or particularly opake part, to be perceived, which may determine one to ſuppoſe it the ſtomach, or other of the inteſtines.

Theſe creatures are ſo ſmall, that millions of millions might be contained in an inch ſquare. When viewed ſingly, or ſeparated from one another, they are exceedingly tranſparent, and of a lovely green; but, like all other tranſparent bodies, when numbers of them are brought together they become opake, and loſe their green colour in proportion as the quantity increaſes, till at laſt they appear entirely black.

Notwithſtanding the extreme minuteneſs of theſe animalcula, they ſeem to be fond of ſociety; for on viewing for ſome time a parcel of them taken up at random, they will be ſeen to diſperſe themſelves in a kind of regular order. If a multitude of them are put into a jar of water, they will form themſelves into a regular body, and aſcend ſlowly to the top, where, after they have remained ſome time expoſed to the air, their green colour changes to a beautiful ſky-blue. When they are weary of this ſituation, they form themſelves into a kind of rope, which ſlowly deſcends as low as they intend.

A ſmall quantity of the matter containing theſe creatures having been put into a jar of water, it ſo happened, that one part went down immediately to the bottom, whilſt the other continued floating on the top. After ſome time, each of theſe ſwarms of animalcula began to grow weary of it's ſituation, and had a mind to change it's quarters. Both armies, therefore, ſet out at the ſame time, the one proceeding upwards, and the other downwards; ſo that after ſome hours journey they met in the middle. A deſire of knowing how they would behave on this occaſion engaged the obſerver to watch them carefully, and to his ſurprize he ſaw the army that was marching upwards open to the right and left, to make room for thoſe that were deſcending. Thus without confuſion or intermixture, each held on it's way, the army that was going up marching in two columns to the top, and the other proceeding in one column to the bottom, as if each had been under the direction of wiſe leaders.

### 63. Vibrio Lunula.

Vibrio arcuatus, utraque extremitate æquali, Fig. 16. Bow-ſhaped vibrio, both ends of an equal ſize.

The body reſembles much the ſhape of the moon at the firſt quarter; it is of a green colour, and has generally from ſeven to ten globules diſpoſed lengthways; the ſmaller ones are of a very pale colour, a pale green vacuity may ſometimes be ſeen in the middle: ſome little varieties may be obſerved amongſt them, which are not eaſy to be deſcribed; it will be enough to have given the reader their general and diſtinguiſhing characteriſtics.

## 64. Vibrio Verminus.

Vibrio linearis compreſſus, antice quam poſtice anguſtior. Linear compreſſed vibrio, the fore-part narrower than the hind-part.

A round tranſparent animalculum, or rather a long cryſtalline membrane, the hind-part broader than the fore-part, the apex ſubtruncated, the baſe obtuſe, no perceptible inteſtines, in the middle are two ſpherical veſicules, and a third towards the lower edge. It moves quickly, with an undulatory motion, backwards and forwards; they ſeem to be joined in a very ſingular manner, and are found in great plenty in ſalt water that had been kept ſome days, and was fœtid.

## 65. Vibrio Mallæus.

Vibrio linearis baſi globuli, apice linea tranſverſa. A linear vibrio, with a globule at the baſe, and tranſverſe line at the apex.

This is a white pellucid animalculum, reſembling the letter T, with a globule affixed to the baſe.

It is in motion and at reſt every moment alternately; when in motion it reſembles the letter V, when at reſt the letter T. They are found plentifully in ſpring water.

## 66. Vibrio Acus.

Vibrio linearis, colli, apice obtuſo, cauda ſetacea. Linear vibrio, with a neck, the upper extremity obtuſe, the lower one terminating in a ſetaceous tail.

This vibrio is of the ſhape of a ſewing needle; the neck round, partly tranſparent, and marked in the middle with a red point; the trunk cylindrical, the edges obſcure, the middle bright, and nearly of a triangular appearance, the tail is fine like a briſtle. A motion may be obſerved in the inſide of this little creature. It does not bend the body when in motion.

## 67. Vibrio Sagitta.

Vibrio ſublinearis, colli, apice truncato atro, cauda ſetacea. Somewhat linear in it's appearance, a well-marked neck, the apex truncated and open, the tail ſetaceous.

The body is very long and flexible, broadeſt towards the middle, which is alſo filled with grey molecules; the fore-part is drawn out into a ſtrait tranſparent neck, the upper end of it thick and black. The motion of this animalculum ſeems to be produced by the contraction and extenſion of the neck. It is found in ſalt water.

## 68. Vibrio Gordius.

Vibrio æqualis, caudæ apice tuberculato. Vibrio of an equal ſize throughout, the tail terminated by a little tubercle.

A round animalculum; the fore-part for about one-ſixth of the whole length is tranſparent, and furniſhed with a ſky-coloured alimentary tube; the lower part is bright and pointed, the middle full of ſmall globules; a ſmall knob terminates the tail. Found in an infuſion made with ſalt water.

## 69. Vibrio Serpentulus.

Vibrio æqualis utrinque ſubacuminatus. This vibrio is of an equal ſize, rather pointed at both ends.

It is very ſimilar to the vibrio anguillula, differing principally in the ſhape of the ends, which in this are pointed. It does not adhere to objects by the pointed tail; it is furniſhed with a long row of the moſt minute points.

It's motion is ſerpentine, ſometimes to be met with perfectly ſtrait and ſtill, and is found in infuſions of vegetables after ſome weeks ſtanding; it is of a whitiſh colour, the whole body is frequently convoluted, and drawn into different figures.

### 70. Vibrio Coluber.

Vibrio filiformis, ſeta caudali geneculata. Filiform vibrio, the tail ſetaceous, and bending up nearly to form a right angle with the body.

In this vibrio the mouth, the oeſophagus, the molecules in the inteſtines, and the twiſting thereof, are very conſpicuous. The tail is exceeding ſmall, and bent ſo as to form a conſiderable angle with the body. It is found in river water.

### 71. Vibrio Anguillula.

Vibrio æqualis ſubrigidus. Vibrio of an equal ſize throughout, and ſomewhat hard.

This animalculum may be divided into four varieties, if not diſtinct ſpecies, namely, the anguillula aceti, glutinis farinoſi, aquæ dulcis, et aquæ marini.

### Anguillula Aceti. Vinegar Eel.

Chaos redivivum, Lin. Syſt. Nat. 1326.
Leeuwenhoeck Op. Omn. p. 3, n. 1, f, l, o.
Joblot Obſ. Micr. 1, p. 2, pl. 2.
Hook's Micr. p. 25, fig. 2.
Borelli Obſ. Micr. 1, p. 7.

Power's Micr. Obſ. p. 38.
Baker's Empl. for Micr. p. 10, fig. 8 and 9.
——— Micr. Expl. p. 81, pl. 5, fig. 10.
Adams Micr. Illuſ. pl. 32, fig. 197, A, B, C, D.
Rozier Journal Phyſique, Mars 1775, Janv. & Mars 1776.
Spallanzani Opus, Phy. part 1, p. 83.

### Anguillula Glutinis. Paſte Eel.

Chaos redivivum, Lin. Syſt. Nat. 1326.
Ledermuller Micr.
Baker Micr. Exp. p. 82.
Roz. Journal Phyſique, Mars 1775, Mars 1776.
Adams Micr. Illuſ.

The body is filiform, or like a thread, round, pellucid, replete with little grains in the middle, both extremities very pellucid and empty, the fore-part a little truncated, the hind-part terminating in a very ſhort briſtly point. It is the ſame in every age and ſize.

### Anguillula Fluviatalis.

Corculum vermiculo ſimile Lin. amæn (mund. invis).
Needham Micr. p. 99, pl. 5, fig. 7.
Baker Micr. Expl. p. 80, pl. 5, fig. 9.
Anguille vulgaire, Rozier Journal Phyſique, 1775,
Mars, Nov. 1776.
Ibid, anguille du bled Rachitique.
Ibid, anguille du faux ergot.
Spallanz. Opuſc. Phyſ. part 2, page 354, pl. 5, fig. 10.

The body of this is exceedingly tranſparent; no viſible entrails, though a few tranſverſe lines may be diſcovered on the body. It is ſometimes, though rarely, furniſhed with a long row of little globules, and often with two ſmall oval ones; the tail terminates in a point.

Muller ſays he found theſe eels in the ſediment which is formed by vegetables on the ſides of veſſels in which water has been kept for ſome time.

The eels of paſte have been more diſtinguiſhed than moſt other animalcula, as well on account of the various ſpeculations and theories to which it has given riſe, as their many curious properties. Four different ſpecies of eels may be found in paſte; of the firſt, which has been deſcribed very briefly in page 511, we ſhall now give a more particular deſcription. To be certain of procuring theſe eels, boil ſome flower in water, to which you have added a few drops of vinegar, provide an earthen pot which has a hole at the bottom, fill it with earth, and then put the paſte in a piece of coarſe cloth, and bury it in this earth; the pot is to be expoſed to the ſun in the ſummer, or kept in a warm place in the winter; by this means you will very ſeldom fail of finding in ten or twelve days a large quantity of eels in the paſte.

This eel, when at it's full growth, is about one-tenth of an inch long, and rather leſs than one-hundredth of an inch in diameter: Fig. 6, Plate XI. repreſents one of theſe eels magnified about one hundred and twenty times, only compreſſed ſo much between two plates, by means of an adjuſting ſcrew, as not only to prevent it from moving, but to lengthen and flatten it in a ſmall degree. At the upper part there are two little moveable pieces, or nipples, *a* a, between which an empty ſpace *b* is formed, that terminates in the mouth; the hinder-part is round, but there projects from it a ſhort ſetaceous tail *w*; in the young eels the termination of the tail is not ſo abrupt as in the preſent ſpecimen, but it finiſhes by a gradual diminution. There is probably a vent near z, for the paſſage of the excrements; becauſe when that part has been gently preſſed, two or three jets, of a very ſubtle ſubſtance, have been obſerved to iſſue from it. If the preſſure is increaſed, a ſmall bladder will be forced out, a further compreſſion burſts the bladder, and the bowels are forced through the opening.

A greater degree of magnifying power is neceſſary to obtain an exact idea of the viſcera of theſe eels. Fig. 10 repreſents the alimentary duct (further magnified) from it's origin to the belly. It is ſhewn here as ſeparated from the animal, which is eaſily effected; for nature, aſſiſted by very little art, performs the operation. The oeſophagus, b c, Fig. 6 and 10, at it's origin a a, is very ſmall, but ſoon grows larger, as at c, and forms a kind of oblong bag, c d; the diameter of this increaſes till it comes to d, where it ſwells out as at d e f; it then grows ſmaller till it comes to g, when it again ſwells out as g k l. There is a narrow neck at i, which in it's natural ſtate is ſeen in the bag k l. The part k l is the ſtomach. M. Becli has ſhewn, that the alimentary duct of many ſpecies of worms is formed of two bags, one of which is incloſed within the other. It is the ſame with this animalculum; the little veſſel b c, that we have called the oeſophagus, which is the origin of the bag c d, enters into the ſame bag, and preſerves it's form within it, till it comes to m,

from

from whence it is prolonged in the form of a black line m n n, which paſſes by the axis of the duct e e h, and apparently terminates itſelf at the beginning of the abdomen k. To this tube, near the center of the ſwelling g h i, are fixed two ſmall tranſparent bodies; that end of theſe which is connected with the tube is round, the other end is pointed; theſe ſmall pieces cannot be diſcerned in every poſition of the eel.

We muſt now ſhew how this duct is to be forced out of the eel. The body, when compreſſed, generally burſts either at the head or tail, and always at that part which is leaſt preſſed; hence when the maſs of fluids contained in the body is forced towards the anterior part, they meet with a reſiſtance in paſſing from the abdomen to the duct already deſcribed; the abdomen being forced by the fluids which are made to act againſt it, burſts at the upper part, and the fluids ſtriking againſt the neck g h i, force it, with all it's contents, out of the body, through an opening at the anterior part; on leſſening the preſſure, the bowel, thus diſcharged, will float in the water between the two plates of glaſs.

Not to enter into a detail of thoſe parts which have been ſuppoſed by ſome writers to conſtitute the heart, &c. of theſe minute animalcula, it will be ſufficient here to deſcribe thoſe in which motion may be diſcovered, and to leave the reſt to future obſervations on the ſubject. The parts which may be ſeen in motion within theſe minute creatures are, 1. the ſmall tube, or duct, from it's origin at m, to the two appendages; 2. theſe appendages themſelves; 3. the remainder of the tube, from the appendages to the inſertion at the ventricule k; 4. in the ſwelling g k l. The reſt of this duct, from the beginning by the oeſophagus b c, to the ſecond ſwelling, has no motion. There is a variety in the motions of the firſt part of this duct, ſometimes it dilates and contracts, at other times it has an oſcillatory motion. It is difficult to gain a good view of the appendages, but when the poſition of the little creature is favorable, they ſeem to have a two-fold motion, by which the pointed ends approach to, and then ſeparate from each other, and another by which they move up and down. The part g k l moves backwards and forwards alternately, the motion of each of theſe parts is independent of the reſt. Theſe are the principal parts, whoſe motion is connected with the life of the animal.

The other viſcera that are contained in the body of the eel, and which may be obſerved by the aid of the microſcope, are the veſſels which contain the food, thoſe which are filled with a tranſparent ſubſtance, and the womb, or ovary. The firſt form the abdomen and inteſtines; theſe are filled with a black ſubſtance, which prevents their being properly and clearly diſtinguiſhed; theſe veſſels, in their paſſage through the poſterior part of the body, form an empty ſpace, in which we may perceive that one ſide of the animalculum is occupied by the ovary q q q, which runs from j to u x; it is at theſe two extremities of the ovaries that the eggs begin to be formed, for the largeſt eggs are always to be found in the middle, and the ſmalleſt at the ends, as may be ſeen at j f and u x.

All the eels which bear eggs have two protuberances, y y, formed on the exterior part, near the center of the ovary; it appears like a tranſparent ſemicircular membrane, but is really a kind of hernia, or bag, in which one or two eggs may be ſometimes ſeen; all the larger eels have this appendage, which alſo bears the marks of having been burſt. Now as the younger eels have not this appendage, nor any marks of a rupture, we may reaſonably conclude that it is from hence that the little eels iſſue from the parent.

In the latter part of the year, and during the winter, theſe eels are oviparous, and the young eels may be ſeen to proceed from the egg; at other times they are viviparous, ſix live eels have been ſeen at one time in the belly of the parent, twenty-two eggs have been counted in the ovary. M. Muller ſuſpected that there was a difference of ſex in ſome of theſe animalcula, but it was left to M. Roffredi to afford the proof, and it was only from a variety of repeated obſervations that he could allow himſelf to be convinced of this truth. He continued his reſearches upon the ſame ſubject on other microſcopic eels, and has ſince been able to diſtinguiſh the ſexual parts of the vinegar eels.

The next eel we ſhall deſcribe is the eel of vinegar, Fig. 7, and that becauſe it is oviparous and viviparous; like the preceding it is filiform, but in other reſpects they differ conſiderably. It is longer, not near ſo large, the tail is ſmaller, and more tapering than that of the paſte eel; it moves with much greater eaſe, and is more lively. We may obſerve in ſmall, at the tail of this eel, what may be ſeen at large at the beginning of the viper's tail, a little kind of tongue a b, which ſometimes adheres to the ſkin, at other times is ſeparated from it. An alimentary duct may be eaſily diſcovered, but no other inteſtines can be diſcerned, without deranging altogether the organization of the animalculum.

The ſecond ſpecies of paſte eel is oviparous. It is eaſily diſtinguiſhed from the firſt kind, by being much ſmaller; it is repreſented at Fig. 8. Tne conformation of the alimentary duct and the inteſtines are in general nearly the ſame, though an intelligent obſerver will find out ſome ſpecific differences. By the flexion of the inteſtines c c c, a void ſpace is left a little beyond the middle of the body, where the eggs are collected. There is no exterior protuberance near the ovary, as in the preceding one, but a ſmall hole, l, may be diſcovered, near which are placed two little tubercles f f, though they are very ſeldom to be obſerved without compreſſing the animalcula.

We meet with another eel in paſte, which may with reaſon be called the common eel. It is often to be found in grains placed in the earth, in which the germ is deſtroyed, in the roots and ſtems of farinaceous plants, in the tremella of Adanſon, and in ſeveral ſpecies of conferva, as well as in ſeveral infuſions. This eel, when at it's full growth, is rather longer than the common eel of blighted wheat; one of them is repreſented at Fig. 11. They are eaſily diſtinguiſhed from the eels of blighted wheat, becauſe they have no ranges of globules like it, by the two little protuberances which are near the middle of the body, and by the regular diminution of the tail. It is oviparous.

A very ſmall ſpecies, repreſented at Fig. 9, may alſo be found in paſte; they may be diſtinguiſhed from the young eels of the larger ſort by their vivacity and ſlenderneſs.

## OF THE EELS IN BLIGHTED WHEAT.*

Theſe animalcula were diſcovered by Mr. Needham, and deſcribed by him in a work entitled New Microſcopical Diſcoveries. They are not lodged in thoſe blighted grains which are covered externally with a ſoot-like duſt, (whoſe inſide is often alſo little more than a black powder) but abundance of ears may be obſerved in ſome fields of corn, which have grains that appear blackiſh, as if ſcorched; theſe, when opened, are found to contain a ſoft white ſubſtance, that, when attentively examined, looks like a congeries of threads, or fibres, lying as cloſe as poſſible to each other in a parallel direction, and much reſembling the unripe down of ſome thiſtles. This fibrous matter does not diſcover any ſigns of life or motion, unleſs water be applied to it; the fibres then ſeparate, and prove themſelves to be living creatures.

Theſe eels are in general of a large ſize, and may be ſeen with a common magnifying glaſs, being about one-thirtieth of an inch in length, and one hundred and fortieth broad. Fig. 5 repreſents one of them magnified about one hundred and twenty times; they are in general of a bright cheſnut colour, the extremity a b is whiter and more tranſparent than the reſt of the body. The end a is rather round, the end b is pointed. A diſtinguiſhing mark of theſe little creatures is a row of tranſparent globules, which are placed at intervals through the whole length of the body, beginning at b, where the tranſparency of the fore-part ceaſes, and going on to the extremity c. They are in diameter rather leſs than one-third of the body. Another peculiar mark is a ſmall lunular tranſparent ſpace *c* near the middle of the body. This part is tranſparent, and is free from the coloured matter of the inteſtines; there is a neck in the inteſtines near this ſpace, which confines them to one part of the body.

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* Bled avorti.

Great care ſhould be taken by the obſerver not to burſt the ſkin of the eels in diſengaging them from the grain, for they never break or burſt of themſelves; but if broke, viſible inteſtines, filled with a black matter, ruſh out of the body, from which little black globules are diſengaged, which ſwim ſlowly about the water, but without any principle of internal motion; when the obſervation is made, immediately after the grains proceed from the eel; but if the eels that are broke are left long in the water, the ſame phænomena will take place, as in other animal and vegetable infuſions. It is owing to not properly attending to theſe circumſtances, that we may attribute many of the fanciful poſitions of M. Needham, which were deduced from ill-conducted experiments, and which, when properly examined, are found to be in a great meaſure falſe.

M. Roffredi ſowed ſome of the grains of this wheat, which ſprang up; but the ear was either wholly or in a great part ſpoiled, being filled with theſe eels. He alſo found them in other parts of the plant; to diſengage them from the plant, it muſt be ſoaked in water, and then compreſſed a little. At firſt ſight theſe eels ſeem to reſemble the foregoing, but a more accurate inſpection ſhews that they have not the ſame curious diſpoſition of the internal globules, nor the ſame tranſparent place in the middle of the body. The inteſtinal bag leaves indeed in theſe an empty ſpace, but it is of an indetermined form. The animalcula from the plant are much more lively than thoſe which are procured from the dried grains.

The principal phænomena of this kind of blighted wheat is probably owing to theſe animalcula, who prevent the regular circulation of the ſap. They increaſe in their ſize in a certain proportion to the plant, ſo that at laſt they may be obſerved with great eaſe by the naked eye, being two-tenths of an inch long, and nearly one-tenth in diameter. Fig. 4 repreſents one of theſe magnified nearly in the ſame proportion as Fig. 5; a a the ovary, which may be traced almoſt from the lower extremity to the middle of the body, where the body becomes ſo opake as to prevent it's being ſeen any further. The eggs, when arrived at their full growth, are nearly of a cylindric ſhape, both ends rounded; towards the extremity b there are two little protuberances d d, through which the eggs are moſt probably extruded; theſe protuberances are not always viſible. The eggs are formed of a fine tranſparent membrane; it covers the young eel, which is folded curiouſly therein; theſe eggs may often be found in the plant.

A moſt ſatisfactory view of theſe eels is obtained by examining them with the ſolar microſcope; it affords one of the moſt ſurprizing and magnificent ſpectacles; two generations may be often ſeen, one which draws near the allotted period of it's exiſtence, and another which only begins to enjoy the bleſſings of life. Some arrived at their full growth, others quite ſmall, &c. In ſome we may perceive the young animalcula in motion in the eggs, in others no ſuch motion can be obſerved; with a variety of other circumſtances too tedious to enumerate, though they afford great pleaſure to the ſpectator.

One of the moſt remarkable circumſtances in theſe animalcula is the faculty they have of receiving again the powers of life, after having loſt them for a conſiderable time; for inſtance, when ſome of theſe blighted grains, that have been preſerved for many years, have been ſoaked in water for ten or twelve hours, you will find in it living eels of this ſpecies; if the water evaporates, or begins to fail, they ceaſe to move, but on a freſh application will be again revived.

It may be proper to notice here, that according to the obſervations of M. Roffredi, thoſe eels which have done laying of eggs are incapable of being reſuſcitated upon being moiſtened; the ſame ſeems to be alſo the caſe with thoſe that are very young; it is probable they muſt attain a certain age and degree of ſtrength before they are endowed with this wonderful faculty.

In the month of Auguſt, 1743, a ſmall parcel of blighted wheat was ſent by Mr. Needham to Martin Folkes, Eſq. Preſident of the Royal Society, (with an account of his then new diſcovery) which parcel the preſident was pleaſed to give to Mr. Baker, deſiring him to examine it carefully; in order ſo to do, he cut open ſome of the grains that were become dry, took out the fibrous matter, and applied water to it on a ſlip of glaſs, but could diſcern no other motion than a ſeparation of the fibres or threads, which ſeparation he imputed wholly to an elaſticity in the fibres; and perceiving no token of life, after watching them with due care, and repeating the experiment till he was weary, an account thereof was written to Mr. Needham, who having, by trials of his own, found out the cauſe of this bad ſucceſs, adviſed him to ſteep the grains before he attempted to open them; on doing which, he was very ſoon convinced of his veracity, and entertained with the pleaſing ſight of this wonderful phænomenon. At different times after this, Mr. Baker made experiments with grains of the ſame parcel, without being once diſappointed. He ſoaked a couple of grains in water for the ſpace of thirty-ſix hours, when believing them ſufficiently moiſtened, he cut one open, and applying ſome of the fibrous ſubſtance to the microſcope in a drop of water, it ſeparated immediately, and preſented multitudes of the anguillæ, without the leaſt motion or ſign of life; but being taught by experience that they might notwithſtanding poſſibly revive, he left them for about four hours, and then examining them again, found much the greateſt number moving their extremities pretty briſkly, and in an hour or two after they appeared as lively as theſe creatures uſually are. Mr. Folkes, and ſome other friends, were witneſſes of this experiment. We find an inſtance here that life may be ſuſpended, and ſeemingly deſtroyed; that by an exhalation of the fluids neceſſary to a living animal, the circulations may ceaſe, all the organs and veſſels of the body may be ſhrunk up, dried, and hardened; and yet, after a long while, life may begin anew to actuate the ſame body, and all the animal motions and faculties may be reſtored, merely by repleniſhing the organs and veſſels with a freſh ſupply of fluid. Here is a proof that the animalcula in the grains of blighted wheat can endure having their bodies quite dried up for the ſpace of four years together, without being thereby deprived of their living power.

It appears plainly from the foregoing experiments, that when the blighted grains of wheat have been kept a long time, and the bodies of theſe animalcula are conſequently become extremely dry, the rigidity of their minute veſſels requires to be relaxed very gently, and by exceeding ſlow degrees; for we find, that on the application of water immediately to the bodies of theſe animalcula, when taken from the dry grains, they do not ſo certainly revive as they do if the grains themſelves be either buried in earth, or ſteeped in water for ſome time before they are taken out: the reaſon of which moſt probably is, that too ſudden a relaxation burſts their delicate and tender organs, and thereby renders them incapable of being any more employed to perform the actions of life; and indeed, there are always ſome dead ones amongſt the living, whoſe bodies appear burſten, or lacerated, as well as others that lie extended and never come to life.

Some diſcretion is needful to adapt the time of continuing the grains in water or earth, to the age and dryneſs of them; for if they are not opened before they have been too much or too long ſoftened, the animalculum will not only ſeem dead, but will really be ſo. Of the two grains he mentions to have been four years old when put to ſoak, he opened one after it had lain thirty-ſix hours, and the event was as already related: the other was let lie for above a week, and on opening found all the anguillæ near the huſk dead, and ſeemingly in a decayed condition; but great numbers iſſued alive from the middle, and moved themſelves briſkly. Unleſs the huſks are opened to let theſe creatures out after they have been ſteeped, they all inevitably periſh; and when taken out and preſerved in water, if the huſks are left with them they will die in a few days; but otherwiſe, they will continue alive in water for ſeveral months together, and, ſhould the water dry away, may be revived again by giving them a freſh ſupply.

As the eels in paſte are an object which are ſo often exhibited in the microſcope, it will be proper, before we leave this ſubject, to inform the reader how he may procure the young eels from the parent animalcula, a diſcovery which was originally made by Mr. Sherwood, but more particularly purſued and deſcribed by Mr. Baker. Take up a very ſmall quantity of paſte where theſe eels abound on the point of a pin, or with a ſharpened quill; lay it on a ſlip of glaſs, and diluting it well with water, many of them will become viſible to the naked eye; then with the nib of a pen, cut to a very fine point, and ſhaved ſo thin as to be extremely pliable, ſingle out one of the largeſt eels, and inſinuate the point of the pen underneath it; remove it into a very ſmall drop of water, which you muſt have ready prepared on another ſlip of glaſs. When thus confined, it may eaſily be cut aſunder tranſverſely, by the help of a good eye and ſteady hand, with a lancet or ſharp penknife; or if the eye is deficient, a hand-magnifier will enable almoſt any-body to perform the operation. As ſoon as the parts are ſeparated, apply your object to the microſcope, and if the diviſion has been made about the middle of the animal, ſeveral oval bodies, of different ſizes, will be ſeen to iſſue forth. Theſe are young anguillæ, of different degrees of maturity, each whereof is coiled up, and included in it's proper membrane, which is of ſo exquiſite a fineneſs, as to be ſcarce diſcernible by the greateſt magnifier while it incloſes the embryo animal. The largeſt and moſt forward break immediately through this delicate integument, unfold themſelves, and wriggle about in the water nimbly; others get out, uncoil, and move about more ſlowly; and the leaſt mature continue entirely without motion. The uterus, or veſſel that contains all theſe oval bodies, is compoſed of many annula, or ringlets, not unlike the aſpera arteria of land animals, and it ſeems to be conſiderably elaſtic; for as ſoon as the operation is performed, the oval bodies are thruſt out with ſome degree of violence, by the ſpringing back or action of this bowel. An hundred or upwards of the young ones have been ſeen to iſſue from one ſingle eel, whereby the prodigious increaſe of them may be accounted for, as probably ſeveral ſuch numerous generations are produced in a ſhort time. Hereby we alſo learn that theſe creatures are not only like eels in ſhape, but are likewiſe viviparous, as eels are generally ſuppoſed to be.

There is ſcarce a more entertaining experiment, in which there is but little riſk of being diſappointed; for they ſeem, like earth-worms, to be all prolific, and unleſs by accident you cut one that has brought forth all it's young before, or make your trials when the paſte has been kept a very long time, (in which caſe they have been found ſometimes unfruitful) you may be ſure of ſucceſs.

### Anguillula Marina.

This, when preſſed between two plates of glaſs, appears to be little more than a cryſtalline ſkin, with a kind of clay-coloured inteſtines. The fore-part of the body is truncated, the lower part drawn out to a fine point, the reſt of the body is of an equal ſize throughout. The younger ones are filled with pellucid molecular inteſtines.

### 72. Vibrio Linter.

Vibrio ventricoſo-ovatus, collo breviſſimo. Ventricoſe oval vibrio, with a ſhort neck.

This is one of the larger animalcula, of an egg ſhape, pellucid, inflated, ſomewhat depreſſed at top; the apex is prolonged into a moveable cryſtalline neck, the belly is replete with pellucid molecules. It is not very common, but is to be found among the lemnæ.

### 73. Vibrio Utriculus.

Vibrio teres, antice anguſtatus truncatus, poſtice ventricoſus. Round vibrio, the fore-part narrow and truncated, the lower ventricoſe.

It does not ill reſemble a bottle in ſhape; the belly is replete with molecular inteſtines, the neck bright and clear, the top truncated; in ſome a pellucid point is viſible at the bottom of the belly. It is in an unceaſing, vehement, and vacillatory motion, the neck moving from one ſide to the other as faſt as poſſible.

### 74. Vibrio Faſciola.

Vibrio antice attenuatus, medio latiuſculus, poſtice acutus. Vibrio with a ſmall fore-part, the middle a little bigger, the hind-part acute.

This is a pellucid animalculum, in the middle are the inteſtines in the form of points; an alimentary pipe, which leſſens gradually in ſize, is alſo perceptible.

The motion of it is quick, darting itſelf up and down the water with great velocity. It is found in water juſt looſened from the froſt, and ſeldom elſewhere.

### 75. Vibrio Colymbus.

Vibrio craſſus, poſtice acuminatus, collo ſubfalcato. Thick vibrio, ſharpened at the end, the neck a little bent.

It is larger than moſt of the vibrios, and not unlike a bird in ſhape. The neck is round, ſhorter than the trunk, of an equal ſize throughout, and of a bright appearance, the apex obtuſe. The trunk is thick, ſomewhat triangular, full of yellow molecules; the fore-part broad, the hinder-part acute, the motion ſlow.

### 76. Vibrio Strictus.

Vibrio elongatus linearis, anticem verſus attenuatus, apice obtuſo. Vibrio lengthened out almoſt to a line, ſmall towards the fore-part, the apex obtuſe.

The body linear, being a membranaceous bright thread, without any flexure; the hind-part thicker, round, and filled with molecules, excepting juſt the end, where there is a ſmall pellucid empty ſpace. The apex is obtuſe, and rather globoſe; it has a power of contracting and drawing in the filiform part.

### 77. Vibrio Anas.

Vibrio oblongus, utroque fine attenuatus, collo cauda longiore. Oblong vibrio, both ends attenuated, the neck longer than the tail.

The trunk round, oblong, opake, and crammed with molecules. Both the fore and the hind-part is prolonged into a pellucid talcy membrane, which the animalculum has a power of retracting at pleaſure. The neck is longer than the tail, and the tail is more acute than the neck. It is moſt generally found in ſalt water; a ſpecies of them have been found in river water, with a longer neck.

### 78. Vibrio Cygnus.

Vibrio ventricoſus, collo adunco. Corpulent vibrio, with a crooked neck.

This animalculum is little more than a moſt pellucid line, crooked at top, prominent in the middle, and ſharp at the end; the fore-part, or neck, is equal in length to the reſt of the body, and three times longer than the hind-part, or tail, the intermediate part ſwelling out, and is full of darkiſh molecules and pellucid inteſtines. It is very ſmall, and the moſt ſlothful of all thoſe which move and advance their necks.

### 79. Vibrio Anſer. Fig. 27 and 29, Plate XXV.

Vibrio ellipticus, collo longo, tuberculo dorſali. Elliptical vibrio, with a long neck, and a little lump on the back.

It is between the vibrio proteus and vibrio falx, and is diſtinguiſhed by the lump b, Fig. 29, on the back, placed behind the neck; from this an even long neck (a) proceeds.

The trunk (d) is elliptic, round, and without any lateral inequality, full of molecules, the hind-part ſharp and bright, the fore-part produced into a bending neck, that is longer than the body; the apex even and whole, blue canals paſſing between the marginal edges, occupying the whole length of the neck; in one of them a vehement deſcent of water to the beginning of the trunk is perceivable.

The motion of the body is ſlow, that of the neck is more lively and flexuous, ſometimes ſpiral. It is found in water where there is duck-weed.

### 80. Vibrio Olor. Fig. 28, Plate XXV.

Vibrio ellipticus, collo longiſſimo, apice nodoſo. Elliptical, with a very long neck, and a knob on the apex.

An animalculum which is continually moving it's lively neck. The form of the body is elliptical and ventricoſe, the hind-part ſomewhat ſharp. It is membranaceous, dilatable, winding variouſly; the hind-part is ſometimes replete with darkiſh molecules.

cules. The neck (d) is three or four times longer than the body, of an equal ſize throughout, except a ſmall degree of thickneſs at the apex (f) very pellucid. The neck is very lively in it's motions, the body ſlow.

Is found in water that is kept for a long time, and which is full of a vegetable greenneſs.

## 81. Vibrio Falx.

Vibrio gibboſus, poſtice obtuſus, collo falcato. A gibbous vibrio, the hind-part obtuſe, the neck crooked.

The body is pellucid, elliptical, the fore-part leſſening into a little round bright neck, nearly of the ſame length as the trunk, the hind-part obtuſe. The trunk itſelf is rather rounding or tending to the gibbous, and filled with very ſmall molecules; there are alſo two bright globules, one within the hind extremity, the other in the middle of the body. The immobility of the neck gives it motions much the reſemblance of a ſcythe.

## 82. Vibrio Intermedius.

Vibrio membranaceus, antice attenuatus, poſtice ſubacutus. Membranaceous vibrio, the fore-part ſmall, the hinder-part ſomewhat acute.

It ſeems to be an intermediate ſpecies between the vibrio falx and the faſciola; it is a thin membrane, conſtantly ſolded. The whole of it is of a cryſtalline talcy appearance, the middle replete with grey particles, of different ſizes; it has all round a diſtinct bright margin, the apex of the neck is truncated, the tail obtuſe.

## VI. CYCLIDIUM.

Vermis inconſpicuus, ſimpliciſſimus, pellucidus, complanatus, orbicularis vel ovatus. A ſimple, inviſible, pellucid, flat, orbicular, or oval worm.

### 83. Cyclidium Bulla.

Cyclidium orbiculare hyalinum. Orbicular bright cyclidium.

A very pellucid white animalculum, or orbicular ſkin, the edges a little darker than the reſt. By the aſſiſtance of the compound microſcope, ſome globular cryſtalline-like inteſtines are juſt perceptible. It moves ſlowly and ſemicircularly. Is found occaſionally in an infuſion of hay.

### 84. Cyclidium Millium.

Cyclidium ellipticum cryſtallinum. Elliptic and cryſtalline cyclidium.

It is very pellucid, and more ſplendid than chryſtal, membranaceous, elliptical; a line is perceived through the whole length of it, a point in the fore-part, the hinder-part getting darker. It's motion ſwift, fluttering, and interrupted; it is probable that both extremities are ciliated.

### 85. Cyclidium Fluitans.

Cyclidium ovale cryſtallinum. Oval cryſtalline cyclidium.

This is one of the ſmalleſt animalcula. The body of an oval, or rather a ſuborbicular ſhape, depreſſed, cryſtalline; two ſmall blue ſpaces may be diſcovered, by the aſſiſtance of the microſcope, at the ſides of this little creature.

### 86. Cyclidium Glaucoma.

Cyclidium ovatum, interaneis ægre conſpicuis. Oval cyclidium, the inteſtines perceived with difficulty.

A pellucid oval body, both ends plain, or an oval membrane, with a diſtinct well-defined edge; the inteſtines, when it is empty, are ſo tranſparent, that they are with difficulty diſcerned; being full, they are manifeſted by their green colour; dark globules are diſcoverable in the middle.

In plenty of water it moves ſwiftly in a circular and diagonal direction; whenever it moves ſlowly it ſeems to be taking in water, the inteſtines are then alſo in a violent commotion. Two of the ſmaller ones may often be perceived cohering to each other, and drawing one another by turns; nor are they ſeparated by death, for they remain united even when the water is evaporated. The unſkilful in obſervation muſt be careful leſt they miſtake the ſhade in a ſingle one for a junction of two, or the junction of two for a copulation, for they generate by diviſion.

### 87. Cyclidium Nigricans.

Cyclidium oblongiuſculum, margine nigricans. Oblong cyclidium, with a black margin.

It is very ſmall, pellucid, flat, and with a black margin. With a ſmall magnifier it may be miſtaken for an enchelis.

### 88. Cyclidium Roſtratium.

Cyclidium ovale, antice mucronatum. An oval cyclidium, the fore-part pointed.

This is an oval, ſmooth, and very pellucid animalculum, the fore-part produced into an obtuſe point; with this it feels and examines bodies. It is probably ciliated, though the hairs have not been diſcovered.

The inteſtines are filled with a blue liquor, forming in a tube, which, from the aperture to the middle of the body, is divided into two legs, or branches; beyond the middle there are two little tranſverſe blue lines. The colour ſometimes vaniſhes, and then only veſicular inteſtines are diſcerned.

### 89. Cyclidium Nucleus.

Cyclidium ovale, poſtice acuminatum. An oval cyclidium, the hind-part pointed.

The body is pellucid, depreſſed, the fore-part obtuſely convex, the hind-part acute, the inteſtines veſicular, the fore and hind-part on each ſide dark. It reſembles a grape-ſeed.

## 90. Cyclidium Hyalinum.

Cyclidium ovatum, poſtice acutum. Oval cyclidium, the hind-part acute.

This cyclidium is oval, flat, and bright, without any viſible inteſtines, the hinder-part ſomewhat ſmaller than the fore-part; it has a tremulous kind of motion.

## 91. Cyclidium Pediculus.

Cyclidium ovale convexum, ſubtus planum. An oval convex cyclidium, the bottom even.

Trembley Polyp. 1. p. 282.

This is a gelatinous white animalculum, the bottom over the back gibbous, the extremities depreſſed and truncated, ſometimes one end ſeems cloven into two points, perhaps this is the aperture of the mouth.

It runs upon the hydra pallida as if it had feet, going back again every moment. It is ſcarce ever ſeen but on the arms and the body of the hydra.

### 92. Cyclidium Dubium.

Cyclidium ovale, ſupra convexum; ſubtus cavum. Oval cyclidium, the upper part convex, the under part concave.

This is one of the larger ſpecies, the body is of an oval ſhape, one ſide is convex, the other is concave, the margin is pellucid, the inner part contains a great number of black molecules.

## VII. PARAMÆCIUM.

Vermis inconſpicuus, ſimplex, pellucidus, membranaceus, oblongus. An inviſible, ſimple, pellucid, membranaceous, flat worm.

### 93. Paramæcium Aurelia.

Paramæcium compreſſum, verſus anticam plicatum, poſtice acutum. Paramæcium compreſſed, oblong, folded towards the fore-part, the hinder-part acute.

### Volvox Terebella. Ellis.

This is rather a large animalculum, membranaceous, pellucid, four times longer than it is broad, the fore-part obtuſe, tranſparent, without inteſtines, the hind-part replete with molecules of various ſizes; the fold which goes from the middle to the apex is a ſtriking characteriſtic of the ſpecies, forming a kind of triangular aperture, and giving it ſomewhat the appearance of a gimlet. It's motion is rectilinear, vacillatory, and generally vehement.

They may often be ſeen cohering lengthways; the lateral edges of both bodies appear bright. They may alſo ſometimes be ſeen lying on one another by turns, and ſometimes cohering by the middle. They live many months in the ſame water if it is not renewed. They are to be found in June, in ditches where there is plenty of duck-weed.

### 94. Paramæcium Chryſalis. Fig. 26, Plate XXV.

Paramæcium cylindraceum, verſus anticam plicatum, poſtice obtuſum. Cylindrical paramæcium, folded towards the fore-part, the hinder-part obtuſe.

It differs but very little from the preceding, only the ends (a b) are more obtuſe; the margin is filled with black globules, and it is an inhabitant of ſalt water.

### 95. Paramæcium Verſutum.

Paramæcium cylindraceum, poſtice incraſſatum, utraque extremitate obtuſum. Cylindrical paramæcium, the lower part thick, and both ends very obtuſe.

An oblong body, green, gelatinous, filled with molecules, the lower part thick, the fore-part ſmaller, both ends obtuſe, and may be ſeen to propagate by diviſion. Is found in ditches.

### 96. Paramæcium Oviferum. Fig. 25, Plate XXV.

Paramæcium depreſſum, intus bullis ovalibus. Paramæcium depreſſed, with large oval molecules within ſide.

A membranaceous, oval, oblong animalculum, grey, pellucid, having many oval very pellucid corpuſcles (a) diſperſed about the body, and many black grains towards b.

### 97. Paramæcium Marginatum. Fig. 24, Plate XXV.

Paramæcium depreſſum, griſeum, margine duplici. Paramæcium depreſſed, grey, with a double margin.

This is one of the largeſt of this claſs, flat, elliptical, every part filled with molecules, except the lower end (b), where there is a pellucid veſicle; this animalculum is ſurrounded by a broad double margin; when expiring, a bright ſpiral inteſtine may be ſeen. (a), Fig. 24, the apex, (b) the veſicle, (c) the ſpiral inteſtine.

## VIII. KOLPODA.

Vermis inconſpicuus, ſimpliciſſimus, pellucidus, complanatus, ſinuatus. An inviſible, very ſimple, pellucid, flat, crooked worm.

### 98. Kolpoda Lamella.

Kolpoda elongata membranacea, antice curvata.

This animalculum is a pellucid membrane, long and narrow, the hind-part obtuſe, narrower, and curved towards the top; no inteſtines diſcoverable, only a ridge, or fold, going through the middle. It's motion is vacillatory and ſingular, moving to and fro on it's edge, not on the flat ſide, as is uſual with moſt microſcopic animals. It is found in water, but is very ſeldom to be met with.

### 99. Kolpoda Gallinula.

Kolpoda oblonga, dorſo antico membranaceo hyalino. Oblong kolpoda, the back towards the fore-part bright and membranaceous.

The apex rather bent, the belly oval, convex and ſtriated. It is found in fœtid ſalt water.

### 100. Kolpoda Roſtrum.

Kolpoda oblonga, antice uncinata. Oblong, the fore-part hooded.

The fore part is bent into a kind of hook, the hind-part is obtuſe, and every-where filled with black molecules. One of the edges, from the fore-part to the middle, is often ſo blunted and dilated that the reſt of the body appears quite ſmooth, and that part thick and triangular. It's motion is ſlow and horizontal. It is to be found in water where there is lemna, but not often.

### 101. Kolpoda Ochrea.

Kolpoda elongata, membranacea, apice attenuato, baſi in angulum rectum producta. Kolpoda long, membranaceous, the apex attenuated, the baſe bent in a right angle to the body.

A large animalculum, long, and of a ſingular figure, depreſſed, membranaceous, flexible; one edge nearly ſtrait, the other ſomewhat bent, filled with obſcure molecules, and a few little bladders diſperſed here and there; the apex bright and ſmall, the baſe projecting like the human foot from the leg.

### 102. Kolpoda Mucronata.

Kolpoda membranacea dilatata, antice anguſtata, altero margine inciſa. Membranaceous dilated kolpoda, the fore-part ſmaller than the hind-part, with a ſmall inciſion at one ſide.

This animalculum is a dilated bright membrane, the apex an obtuſe point, a broad marked border running entirely round it; within the margin it is filled with grey molecules, a fleſhy diſc on one ſide, which terminates in a ſplendid little point on the other ſide the diſc. It has a truncated appearance.

### 103. Kolpoda Triquetra.

Kolpoda obovata depreſſa, altero margine retuſo. Kolpoda nearly of an egg-ſhape, one edge turned back.

This animalculum ſeems to conſiſt of two membranes, the upper ſide flattened, the lower convex; the apex is bent ſo as to form a kind of ſhoulder. It was found in ſalt water.

### 104. Kolpoda Striata.

Kolpoda oblonga, ſubarcuata depreſſa, candida antice acuminata, poſtice rotundata. Oblong, ſomewhat of a pear-ſhape, white, the fore-part pointed, the hind-part round.

It is very pellucid and white, the upper part rather bent, and terminating in a point, the lower part obtuſely round; at the apex, or mouth, there is a little black pellucid veſicle; when a very great power is uſed, the body appears covered with long ſtreaks; the lower extremity is furniſhed, like many other animalcula, with very ſmall globules. Is to be found in ſalt water.

### 105. Kolpoda Nucleus.

Kolpoda ovata, vertice acuto. Egg-ſhaped kolpoda, with an acute vertex.

It is of an oval ſhape, the vertex pointed, of a brilliant tranſparency, which renders the viſcera viſible; they conſiſt of a heap of round diaphanous veſicules.

106. Kol-

### 106. Kolpoda Meleagris.

Kolpoda mutabilis antice uncinata, poſtice complicata. Changeable, with the fore-part like a hook, the hind-part folded up. Fig. 22, Plate XXV.

A moſt ſingular animalculum, of the larger ſpecies; it has a dilated membrane, with the fineſt folds, which it varies and bends in a moment; the fore-part of the body to the middle is clear and bright, the hind-part variouſly folded in tranſverſe elevated plaits, and full of molecules; the apex turned into a hook, the margin ſinuous, and beneath the apex denticulated with three or four teeth; or in ſome which are more beautifully wrought, the edge is obtuſely notched, and ſet with ſtill ſmaller notches; in the hind-part there are twelve or more equal pellucid globules. It moves ſometimes in a ſtrait, ſometimes in a crooked line. Fig. 22, Plate XXV. a the hooked apex, b the denticulated margin, c the ſeries of globules, d the folded part at bottom.

### 107. Kolpoda Aſſimilis.

Kolpoda depreſſa, non plicatilis apice uncinato, margine antico ad medium, uſque crenulato poſtice, dilatato acutiuſculo. Kolpoda depreſſed, the apex turned in the form of a ſmall hook, the margin of the fore-part notched from the top to the middle, the lower part ſwells out, then diminiſhes again into a ſhort point. It is never folded like the foregoing; it has an elliptic maſs in the middle. It was found on the ſea-coaſt.

### 108. Kolpoda Cucullus. Fig. 23, Plate XXV.

Kolpoda ovata ventricoſa, infra apicem inciſa. Egg-ſhaped ventricoſe, with an inciſion in the fore-part.

It is very pellucid, with a well-defined margin, filled with little bright veſicles, differing in number and ſize. The figure of the moſt part is oval, the top bent into a kind of an obtuſe beak, ſeldom an acute one, but ſometimes oblong. It's inteſtines are formed of from eight to twenty-four bright little veſicles, theſe are not conſpicuous in the young ones; ſome have ſuppoſed that theſe were animalcula that had been ſwallowed by the kolpoda, but Mr. Muller thinks they are the offspring of the kolpoda. In ſome only one cryſtalline veſicle occupies the middle of the body. When the water is almoſt exhaled, and death nigh, it moves more ſlowly than uſual, and protrudes it's offspring with violence.

It moves in general with great vivacity, and in all directions. a the cap or hood, b the inciſion. It is found in infuſions of vegetables, and in fœtid hay. In ſome few a tranſparent membranaceous ſubſtance may be perceived projecting beyond the beak, and reſembling an exuvia; the ſame may be obſerved in the enchelis vibrio, and it is probable that a decortation or caſting of the ſkin has place in theſe animalcula, as well as in inſects.

### 109. Kolpoda Cucullulus.

Kolpoda oblonga, infra apicem oblique inciſa. Kolpoda oblong, with an oblique inciſion a little below the apex.

A very pellucid cryſtalline animalculum; it is furniſhed with ſeveral pellucid globules; there is a bending a little beneath the top, which in ſome poſitions is very diſtinctly ſeen, in others not. It was obſerved in an infuſion of the ſonchi arvenſis.

### 110. Kolpoda Cucullio.

Kolpoda ovalis depreſſa, infra apicem tantillum ſinuata. Flat oval kolpoda, with a ſmall degree of bending beneath the apex.

This is an oval, or rather an elliptical kolpoda, flat on the upper ſide, convex on the under ſide, membranaceous and bright, the fore-part clear; from the middle to the hinder-part it is filled with ſilver-like globules. It often ſtretches out the fore-part, and folds it in different poſitions.

### 111. Kolpoda Ren.

Kolpoda craſſa medio ſinuata. This kolpoda is thick, and curved in the middle.

The body is yellow, thick, and rather opake, even where round, curved a little in the middle, ſo as to have the appearance of a kidney; the whole body is filled with molecules. It's motion is quick, vacillatory, and interrupted. If the water in which it ſwims fail, it aſſumes an oval form, is compreſſed, and at laſt burſts. It is found in an infuſion of hay, generally about thirteen hours after the infuſion is made.

### 112. Kolpoda Pirum. Fig. 20 and 21, Plate XXV.

Kolpoda convexa, ovalis, apice in roſtrum producta. Convex kolpoda, oval, the apex formed into a kind of beak.

The body is uniform and tranſparent, without any ſenſible inequality, the neck rather long, and a little bent; it is of a pale colour, and furniſhed with obſcure little globules. Fig. 20 repreſents this animalculum, 21 the ſame dividing to form another, a the fore-part, b the hind-part, c where it is dividing.

### 113. Kolpoda Cuneus.

Kolpoda clavata, teres, apice dentata. Clavated kolpoda, round, the apex dentated.

This is a large animalculum, the body white, gelatinous, without any diſtinct viſcera. On the fore-part at one ſide there is a pellucid, bright, ſtriated puſtule; the apex is diſtinguiſhed by three or four teeth, the hinder-part is ſmaller than the fore-part, with an obtuſe termination, which it can bend in a ſpiral form.

IX. Go-

## IX. GONIUM.

Vermis inconſpicuus, ſimpliciſſimus, complanatus, angulatus. An inviſible, ſimple, ſmooth, angular worm.

### 114. Gonium Pectorale. Fig. 17, Plate XXV.

Gonium quadrangulare, pellucidum moleculis ſedecim ſphæricis. This gonium is quadrangular, pellucid, with ſixteen ſpherical molecules.

Theſe ſixteen little oval bodies are nearly equal in ſize, of a greeniſh colour, pellucid, and ſet in a quadrangular membrane, like the jewels in the breaſt-plate of the high-prieſt, reflecting light on both ſides. It's animality is evinced by it's ſpontaneous motion, advancing alternately towards the right and left; theſe little bodies ſeem oval when in motion, round when at reſt; the four interior ones are a little larger than the reſt. Found in pure water.

### 115. Gonium Pulvinatum.

Gonium quadrangulare, opacum, pulvillis quatuor. Quadrangular, opake, with four little pillows.

This appears under the microſcope as a little quadrangular, membrane, plain on both ſides; with a deeper lens it looks like a bolſter, formed of three or four cylindric pillows, flattened or ſunk here and there. Thus it appeared to M. Muller on the firſt examination; ſome days after, all the ſides were plain, without any convexity, and divided into little ſquare ſpaces by lines croſſing each other. Found upon dunghills.

### 116. Gonium Corrugatum.

Gonium quadrangulare, albidum, medio correptum. Quadrangular gonium, white, ſunk a little in the middle.

It is ſomewhat of a ſquare ſhape, very minute, without any viſible viſcera, a little depreſſed in the middle. It is found in various infuſions; in ſome poſitions it appears ſtreaked.

### 117. Gonium Rectangulum.

Gonium rectangulum, dorſo arcuato. This gonium is rectangular, the hind-part arched.

It differs from the preceding one but little, the angle at the baſe a right one, the larger veſicle is tranſparent, the reſt green.

### 118. Gonium Truncatum.

Gonium obtuſangulum, poſtice arcuatum. Gonium with obtuſe corners, the hind-part arched.

Much larger than the foregoing, the fore-part is a ſtrait line, the ſides forming therewith obtuſe angles, the ends of theſe ſides are united by a curved line; the internal molecules are of a dark green, there are two little bright veſicles in the middle, it's motion is languid. It is but rarely met with, and then moſtly in pure water.

## X. Bursaria.

Vermis ſimpliciſſimus, membranaceus, cavus. A very ſimple, hollow, membranaceus worm.

### 119. Burſaria Truncatella.

Burſaria ventricoſa, apice truncata. Ventricoſe burſaria, the top truncated.

An animalculum that is viſible to the naked eye, white and oval, truncated at the top, where there is a large aperture, the opening that forms the aperture deſcending towards the baſe; at the bottom of moſt of them there are three or five yellow eggs.

It moves itſelf at pleaſure from right to left, and from left to right, aſcending to the ſuperficies of the water in a right line; ſometimes it rolls about while deſcending.

### 120. Burſaria Bullina.

Burſaria cymbæformis, antice labrata. Boat-ſhaped burſaria, the fore-part formed into a lip.

A pellucid cryſtalline animalculum, furniſhed with ſmaller and larger ſplendid globules ſwimming about within it, the under-ſide convex, the upper-ſide hollow, the fore-part forming a kind of lip.

### 121. Burſaria Hirundinella. Fig. 19, Plate XXV.

Burſaria utrinque laciniata, extremitatibus productis.

Burſaria with two little projecting wings, one on each ſide, the fore and hind-part produced ſo as to give them ſome reſemblance to the head and tail of a bird. It is inviſible to the naked eye; but appears to be a pellucid hollow membrane under the microſcope. They have no viſible inteſtines; it moves ſomewhat like a ſwallow; a the head, b the tail, c one of the wings.

### 122. Burſaria Duplella. Fig. 18, Plate XXV.

Burſaria elliptica, marginibus inflexis. Elliptic burſaria, with the edge bent in and out.

A cryſtalline membrane folded up, no viſible inteſtines, if we except a little congeries of points under one of the folds. Was found among duck-weed.

### 123. Burſaria Globina.

Burſaria ſphærica, medio pellucentiſſima. Spherical burſaria, very pellucid in the middle.

A ſubſpheric hollow animalculum, the lower end furniſhed with black molecules of various ſizes, the fore-part with obſcure points, the reſt entirely empty, and the middle very pellucid; it moves ſlowly from right to left.

## XI. Cercaria.

Vermis inconſpicuus, pellucidus, caudatus. An inviſible pellucid worm with a tail.

### 124. Cercaria Gyrinus.

Cercaria rotundata, cauda acuminata. This cercaria is round, and has a ſharp tail.

The body is white, gelatinous, without any traces of inteſtines; the fore-part ſomewhat globular, the hind-part round, long, and pointed; ſometimes it appears a little compreſſed on each ſide. The tail is in a continual vibration while it is ſwimming, like that of the tadpoles. It ſeems very ſimilar to the ſpermatic animalcula.

### 125. Cercaria Gibba.

Cercaria ſubovata convexa, antice ſubacuta, cauda tereti. Somewhat of an oval ſhape, convex, the fore-part rather acute, the tail round.

It is a ſmall animalculum, gelatinous, white, opake, without any viſible inteſtines, the upper part convex or gibbous; many of them were found in an infuſion of hay, alſo in other infuſions.

### 126. Cercaria Inquieta. Fig. 31 and 32, Plate XXV.

Cercaria mutabilis convexa, cauda lævi. Changeable convex cercaria, with a ſmooth tail.

This animalculum ſo often changes the form of it's body, that it is not eaſy to deſcribe it; it is ſometimes ſpherical, ſometimes like a long cylinder, at others of an oval figure, white, gelatinous, the tail is filiform and flexible, the upper part vibrating vehemently, no viſible viſcera, a pellucid globule may be obſerved at the baſe, and two very ſmall black points placed near the top at d, Fig. 32; whether they are eyes to the animalculum is not known. Was found in ſalt water. a, Fig. 31, the body, b the tail.

### 127. Cercaria Lemna, Fig. 33, 34, and 35.

Cercaria mutabilis, ſubdepreſſa, cauda annulata. Mutable cercaria, ſomewhat flattened, with an annulated tail.

This animalculum puts on ſuch various forms, that at firſt ſight it appears like the proteus of Baker, though it is altogether different.

The body is capable of being contracted or extended, of the ſhape of an oblong pear, or triangular, kidney-ſhaped. The tail ſhort, thick, and annulated, ſometimes long, bending, cylindric, and without rings. It vibrates, when it is ſtretched out, with ſo much velocity, that it appears as it were double. The inteſtines not very diſtinct, near the apex a ſmall pellucid globule is perceivable, that Muller takes to be it's mouth; two black points which are near it, but with difficulty diſcovered, he ſuppoſes to be the eyes. It draws the tail ſometimes into the body. Fig. 33, a, the body rather ſpherical, b the tail; Fig. 34, c, the triangular body; Fig. 35, the body extended, e e the eyes, f f the bowels, g a large veſicle, b a ſmaller one.

It walks ſlowly after taking three or four ſteps; it extends the tail, erecting it perpendicularly, ſhaking and bending it; in this ſtate it reſembles much the leaf of the lemna.

### 128. Cercaria Turbo. Fig. 30, Plate XXV.

Cercaria globuloſa, medio coarctata, cauda uniſeta. Globular cercaria, the middle contracted, with a tail like a briſtle.

Partly of án oval, and partly of a ſpherical ſhape, pellucid, and of a talcy appearance. It ſeems to be compoſed of two globular bodies, the lower one being the ſmalleſt; this figure is occaſioned by the contraction at the middle. There are two black points, like eyes, at the upper part of the animalculum, even with a tranſverſe line which croſſes the top of this little creature; ſeveral large globules may be diſcerned, the tail is ſometimes quite ſtrait, ſometimes turned back on the body. It is to be met with among the duck-weed.

### 129. Cercaria Poduria. Fig. 37 and 38, Plate XXV.

Cercaria cylindracea, poſtice acuminata ſubfiſſa. Cylindric cercaria, the hind-part ſharp, and ſomewhat cloven.

It reſembles the young ones of the podura which live among the lemna, is pellucid, and ſeems to conſiſt of a head, a trunk, and a tail; the fore-part reſembles the head of a herring, the trunk is cylindric, and replete with black ſpiral inteſtines; appears more or leſs ventricoſe, at the will of the animal. Nothing to be diſcovered in the hinder-part. The tail, in moſt ſituations, appears divided into two briſtles. When the animal moves, there is a continual motion among the inteſtines, which, from the various ſhades they occaſion, make the body appear very rough; ſome lateral hairs (cilia) are ſometimes perceived. It moves from one place to another, turning round at the ſame time as upon an axis. It is to be found in November and December, in marſhy places that are covered with lemna. Fig. 36, a the head, b the trunk, c the tail, d with one point, it is ſeen at e, Fig. 37, with two points; f the hairs on the ſide.

### 130. Cercaria Viridis.

Cercaria cylindracea mutabilis, poſtice acuminata fiſſa. Cylindrical cercaria, mutable, the lower end ſharp, and divided into two parts.

This animalculum, when in it's longeſt ſtate, is not unlike the preceding; but from the changes to which the body is ſubject, as well as the colour, it differs conſiderably from it. It ſometimes contracts the head and tail, ſo as to form a ſpherical figure; at others the ſides project outwards. Is found in the ſpring, in ditches of ſtanding water.

### 131. Cercaria Setifera.

Cercaria cylindracea, antice anguſtior, poſtice acuminata. Cylindric cercaria, the fore-part ſmalleſt, the hind-part pointed.

This is a ſmall cercaria, the body rather opake, round, the upper part bright, and ſmaller than the reſt; the trunk is more opake, the tail ſharp, near it is a little row of ſhort hairs. It has a ſlow rotatory motion, and is ſeldom to be met with, and when found it is in ſalt water.

### 132. Cercaria Hirta.

Cercaria cylindrica, antice ſubtruncata, poſtice obtuſa, bimucronata. Cylindrical cercaria, the fore-part ſomewhat truncated, the lower part obtuſe, finiſhing with two ſmall points.

A cylindrical opake animalculum, with two ſmall points at the lower end, moveable, yet rigid, and placed at ſome diſtance from each other; when in motion, the body ſeems as if it was ſurrounded with rows of ſmall hairs, ſeparated a little from each other. It was obſerved in ſalt water.

### 133. Cercaria Crumena.

Cercaria cylindraceo-ventricoſa, antice oblique truncata, cauda lineari bicuſpidata. Cylindrical ventricoſe cercaria, the fore-part obliquely truncated, the tail linear, terminating with two diverging points.

The body is ventricoſe and cylindrical, muſcular and thick, the lower part ſmall; the upper part terminates in a ſmall, ſtrait neck, like the neck of a pitcher; the body appears wrinkled, the tail terminated as in the definition.

### 134. Cercaria Catellus.

Cercaria tripartita, cauda biſecta. Three-parted cercaria, the tail divided into two parts.

This animalculum is more complex in it's form than many others; it has a moveable head, which is affixed to the body only by a point; an abdomen, which is not ſo wide, but twice as long as the head, replete with inteſtines, and a tail which is ſhorter than the head, narrower than the belly, and terminating in two briſtles; theſe it can unite and ſeparate at pleaſure. It moves with vivacity, though without going far from it's firſt place.

### 135. Cercaria Catelina.

Cercaria tripartita, cauda bicuſpidata. Cercaria diſtinguiſhed into three parts, with a ſhort forked tail.

It differs from the preceding in ſeveral reſpects, being larger, the body thicker, more cylindrical, and the lower part truncated, with two ſhort diverging points projecting from the middle. Was found in a ditch where there was plenty of duck-weed.

### 136. Cercaria Lupus. Fig. 39, Plate XXV.

Cercaria cylindrica, elongata, toroſa cauda ſpinis duabus. Cylindric cercaria, long, the tail furniſhed with two ſpines.

This animalculum is larger than moſt of the cercarias, and has ſome particulars in which it reſembles the vorticella. It is full of muſcles, capable of being contracted or extended; cylindric, compoſed of a head, a trunk, and a tail; the head is larger than the body, the apex turned downwards into a little hook; the tail is like the body, but narrower, terminating in two very bright ſpines, that it extends differently. It ſometimes contracts itſelf into one half it's ſize; then again it extends itſelf to it's uſual form. Was found in water among duck-weed. a the head, b the trunk, c the tail, d d the ſpine thereof.

### 137. Cercaria Vermicularis. Fig. 40.

Cercaria cylindrica annulata, proboſcide exſertili, cauda ſpina duplici. Cylindrical, annulated, with a projecting proboſcis, two ſmall ſpines for the tail.

It is a long, cylindrical, fleſhy, mutable animalculum, divided into eight or nine rings, or folding plaits, the apex either obtuſe or notched into two points, the hind-part rather acute, and terminating in two pellucid thorns; ſometimes a ſwelling is perceived between theſe. It often projects from the inciſion at the apex, a kind of cloven proboſcis. Is found in water where there is duck-weed. d d the points of the fore-part, e the proboſcis.

### 138. Cercaria Forcipata.

Cercaria cylindrica, rugoſa, proboſcide forcipata exſertili, cauda bicuſpidata.

Cercaria cylindrical, wrinkled, with a forked proboſcis, that it can thruſt out, or pull in. It is found in marſhy ſituations.

### 139. Cercaria Pleuronectes. Fig. 38, Plate XXV.

Cercaria orbicularis, cauda uniſeta. Orbicular the tail, conſiſting of one briſtle.

It is membranaceous, rather round, and white. In the fore-part are two blackiſh points. The hind-part is furniſhed with a ſlender ſharp tail. In the middle are orbicular inteſtines of different ſizes; the larger of them are bright. It's motion is vacillatory; in ſwimming, one edge of the lateral membrane is upwards; the other, folded down. Found in water that has been kept ſeveral months.

## 140. Cercaria Tripos. Fig. 38, Plate XXV.

Cercaria ſubtriangularis, brachiis deflexis, cauda recta. Cercaria ſomewhat of a triangular form, two bent arms, and a ſtrait tail.

The body flat, pellucid, triangular, each angle of the baſe of the triangle, or fore-part thereof, being bent down into two linear ears, or arms; the apex of the triangle is prolonged into a tail. It was found in ſalt water; b the tail, a the bent arms.

## 141. Cercaria Cyclidium.

Cercaria ovalis, poſtice ſubemarginata, cauda exterſili. This is oval, the hind-part ſomewhat notched, with a tail, that it thruſts out at pleaſure.

It's body is oval, ſmooth, membranaceous, pellucid, with a black margin. The tail is not fixed to the edge, but concealed under it, and coming out from it at every motion, and yet ſo as to project but little from the edge. There is a kind of border to the hinder-part. It's inteſtines are very pellucid veſicles. Is frequently found in pure water.

## 142. Cercaria Tenax.

Cercaria membranacea, antice craſſiuſcula, truncata, cauda triplo breviore. Membranaceous, the fore-part rather thick, truncated, the tail three times ſhorter.

It is an oval, pellucid membrane, ſomething larger than the mona lens. The fore-edge thick and truncated, the hinder-part acute, or terminating in a ſhort tail. It whirls about in various directions with great velocity.

### 143. Cercaria Diſcus.

Cercaria orbicularis, cauda curvata. A ſmall orbicular cercaria, with a bent tail.

### 144. Cercaria Orbis.

Cercaria orbicularis, ſeta caudali duplici longiſſima. Orbicular cercaria, with a tail, conſiſting of two very long briſtles.

### 145. Cercaria Luna.

Cercaria orbicularis, cauda lineari duplici brevi. Orbicular cercaria, with two ſhort ſpines for a tail; the fore-part hollowed, ſo as to form a kind of creſcent.

## XII. LEUCOPHRA.

Vermis inconſpicuus, pellucidus, undique ciliatus. An inviſible worm, pellucid and every where ciliated.

### 146. Leucophra Conflictor.

Leucophra ſphærica, ſubopaca, interaneis mobilibus. Spherical opake leucophra, with moveable inteſtines.

This animalculum, or rather a heap of animalcula, is perfectly ſpherical, and larger than moſt ſpecies of the vorticella; it is ſemi-tranſparent, of a yellow colour, the edges of a dark colour. It is filled with a number of the moſt minute molecules, it rolls at intervals from right to left, but ſeldom removes from the ſpot where it is firſt found.

The innumerable molecules circumſcribed within this ſphere are in continual motion, and, as it were, in vehement conflict, without any order. From the great concourſe of combatants on one ſide, or the other, the ſphere is turned either to the right or left, the molecules going in the ſame direction; it is then tranquil for a ſhort time, but ſoon the conflict becomes more violent, and the ſphere is moved towards the other ſide, and continues to move in a ſpiral line. When the water begins to fail, they aſſume an oblong, oval, or a cylindric figure; the hind-part of ſome is compreſſed into a triangular ſhape, and the tranſparent part eſcaping as it were from the inteſtines, which continue to move with the ſame violence till the water fails, when the molecules are ſpread into an uninformed maſs. But this alſo ſoon vaniſhes, when they ſhoot into the form of the cryſtals of ſal ammoniac, as deſcribed by Baker, p. 3, No. 3.

### 147. Leucophra Mamilla.

Leucophra ſphærica, opaca, papilla exſertili. Sphærical opake leucophra, with a ſmall papillary projection.

It is of a dark colour, and filled with globular molecules, the ſhort hairs are curved inwards; it projects, and draws in occaſionally a little white protuberance, not uncommon in marſhy water.

### 148. Leucophra Viriſcens.

Leucophra cylindracea, opaca, poſtice craſſiore. Cylindrical, opake leucophra, the lower part much thicker than the upper part.

This is a large, pear ſhaped, greeniſh coloured animalculum, filled with opake molecules, and covered with ſhort hairs, generally moving in a ſtrait line. Found in ſalt water.

### 149. Leucophra Viridis.

Leucophra ovalis opaca. Oval, opake leucophra.

Though at firſt ſight it may be taken for a variety of the leucophra viriſcens, yet on a further examination, it differs in many particulars; it cannot lengthen and ſhorten itſelf in the ſame manner that does. It is alſo much ſmaller. Sometimes it is ſeen to be contracted in the middle, as if it was going to be divided in two.

### 150. Leucophra Burſata.

Leucophra viridis, ovalis, antice truncata. Green oval leucophra, the fore-part truncated.

This is ſimilar in many reſpects to the foregoing leucophra, it is a long oval, bulging in the middle, filled with green molecules, every where ciliated, except at the apex, which is truncated, and ſomewhat of the ſhape of a purſe; the hairs larger, and ſometimes collected in little faſcicles. It is to be found in ſalt water.

### 151. Leucophra Poſthuma.

Leucophra globularis, opaca, reticulo pellucenti. Globular opake leucophra, covered as it were with a pellucid net.

Was found in fœtid ſalt water.

### 152. Leucophra Aurea.

Leucophra ovalis, fulva, utraque extremitate æquali obtuſus. Oval yellow leucophra, both ends of it equally obtuſe.

The little hairs are with difficulty diſcovered; it has, in general, a vehement rotatory motion.

### 153. Leucophra Pertuſa.

Leucophra ovalis, gelatinoſa, apice truncato obtuſa, altera latera ſuffoſſa. Oval gelatinous leucophra, the apex obtuſely truncated, one ſide ſunk down.

Gelatinous, yellow, without any ſmall or large molecules; the fore-part truncated, the hind-part brought nearly to a point, a kind of oval hole on one ſide. It was found in ſalt water.

### 154. Leucophra Fracta.

Leucophra elongata, ſinuato angulata ſubdepreſſa. Leucophra long, with ſinuated angles, rather flat.

The body is white, gelatinous, granulated, flat, changing it's form conſiderably.

### 155. Leucophra Dilatata.

Leucophra complanata, mutabilis, marginibus ſinuatis. Smooth changeable leucophra, with a ſinuated edge.

A gelatinous membrane, with a few grey molecules in the fore-part, and a great number in the hinder-part; it is ſometimes dilated into a triangular form, with ſinuated ſides; at other times the ſhape is more irregular and oblong.

### 156. Leucophra Scintillans.

Leucophra ovalis, teres, opaca viridis. Oval, round, opake, green leucophra.

This animalculum is ſuppoſed to be ciliated, from it's bright twinkling appearance, which probably ariſes from the motion it gives the water; it is nearly of an egg-ſhape. Was found in December among the leſſer lemnæ.

### 157. Leucophra Veſiculifera. Fig. 41, Plate XXV.

Leucophra ovata, interaneis veſicularibus. Oval leucophra, with veſicular inteſtines.

An animalculum that is a kind of mean between the orbicular and oval, very pellucid, with a defined dark edge and inſide, containing ſome very bright veſicles, or little bladders. The middle often appears blue, ſo that the little bright veſicles ſeem ſet in a cerulean ſubſtance. Muller could never perceive any of thoſe rays which are mentioned by Spalanzani; he confeſſes, however, that he once ſaw an individual like this environed with very ſmall unequal ſhining rays.

### 158. Leucophra Globuliſera.

Leucophra cryſtallina, ovato-oblonga. Cryſtalline leucophra, of an oblong oval ſhape.

The body is round, very pellucid, without molecular inteſtines, though at one edge it has three little pellucid globules; it is every-where beſet with ſhort hairs. It was found in a ditch where the lemna minor grows.

### 159. Leucophra Puſtulata.

Leucophra ovato-oblonga, poſtice oblique truncata. An oblong oval leucophra, the lower end obliquely truncated.

The body is white, gelatinous, ſomewhat granulated; the lower part is truncated, as if an oblique ſection was made in an egg near the bottom. It is covered with little ſhining erect hairs, at the lower end a few bright puſtules may be diſcovered. It is found in marſhy waters.

### 160. Leucophra Turbinata.

Leucophra inverſe conica, ſubopaca. Leucophra in ſhape like an inverted cone, and rather opake.

It is a round pellucid body, ſomewhat of an acorn ſhape, with a pellucid globule at the lower end. Was found in ſtinking ſalt water.

### 161. Leucophra Acuta.

Leucophra ovata, teres, apice acuto, mutabilis, flavicans. Oval leucophra, round, with the apex acute, mutable, yellow.

Gelatinous, mutable, and thick, the apex bright, the reſt of the body crammed with an innumerable quantity of little ſpherules. It is ſometimes drawn up into an orbicular ſhape, at other times one edge is ſinuated. It was found in ſalt water.

### 162. Leucophra Notata.

Leucophra ovata, teres, punčto marginali atro. Oval leucophra, round, with a black point at the edge.

### 163. Leucophra Candida.

Leucophra hyalina, oblonga, altera extremitate attenuata, curvata. Leucophra of a talcy appearance, oblong, one end ſmaller than the other, and bent back.

The body membranaceous, flat, very white, with no viſible inteſtines, if we except two oval bodies which are with difficulty perceived; the whole edge is ciliated. Found in an infuſion of ſalt water.

### 164. Leucophra Nodulata.

Leucophra ovato-oblonga, depreſſa, ſerie nodulorum duplici. An oblong oval ſpecies of leucophra, with a double row of little nodules.

### 165. Leucophra Signata.

Leucophra oblonga, ſubdepreſſa. Oblong ſubdepreſſed leucophra, with a black margin, filled with little molecular globules, but more particularly diſtinguiſhed by a curved line in the middle, ſomething in the ſhape of a long S; one end of this is at times bent into a ſmall ſpiral. Common in ſalt water, in the months of November and December.

### 166. Leucophra Trigona.

Leucophra craſſa, obtuſa, angulata, flava. Thick, obtuſe, angular, and yellow leucophra.

A triangular yellow maſs, filled with unequal pellucid veſicles, one of which is much larger than the reſt, the edge ſurrounded with little fluctuating hairs. It is not common. Was found in a marſhy ſituation.

### 167. Leucophra Fluida.

Leucophra ſubreniformis, ventricoſa. Leucophra ſomewhat of a kidney ſhape, but ventricoſe.

### 168. Leucophra Fluxa.

Leucophra ſinuata reniformis. Reniform ſinuated leucophra.

### 169. Leucophra Armilla.

Leucophra teres annularis. Round annular leucophra.

### 170. Leucophra Cornuta. Fig. 42 and 43, Plate XXV.

Leucophra inverſe conica, viridis opaca. An inverted cone, green, opake.

It bears ſome reſemblance to the vorticella polymorpha and the vorticella viridis, and requires to be obſerved for ſome time before it's peculiar characters can be aſcertained; the body compoſed of molecular veſicles, of a dark green colour; for the moſt part it is like an inverted cone, the fore-part wide and truncated, with a little prominent horn, or hook, on both ſides, the hind-part being conical, every-where ciliated, the hairs exceeding minute; thoſe in the fore-part are three times longer than theſe, and moving in a circular direction. The hinder-part is pellucid, and ſometimes terminates in two or three obtuſe pellucid projections. The animalculum will at one moment appear oval, at another reniform, and ciliated on the fore-part; at another time the hairs are concealed. When the water evaporates, it breaks or diſſolves into molecular veſicles. It is found late in the year in marſhy grounds. Fig. 42, a the hinder-part pointed, it is obtuſe at b, Fig. 43, e the fore-part, g the cilia, f the horns, h the ſides.

### 171. Leucophra Heteroclita. Fig. 44 and 45.

Leucophra cylindrica, antice obtuſa, poſtice organo criſtato duplici exſertili. Cylindrical leucophra, the fore-part obtuſe, the hind-part furniſhed with a double-tufted organ, which it can thruſt in or out at pleaſure. To the naked eye it appears as a white point, in the microſcope as a cylindrical body, the fore-part obtuſely round, the middle rather drawn in, the lower part round, but much ſmaller than the upper part. With a large magnifying power the whole body is found to be ciliated. The inteſtines are very viſible. It is repreſented in Fig. 44 as it generally appears, in Fig. 45 with the plumed organs. a the fore-part, b the hind-part, d the hooked inteſtines, ii the plumes, g g the ſheaths from which they are projected.

## XIII. TRICHODA.

Vermis inconſpicuus, pellucidus, crinitus. An inviſible, pellucid, hairy worm.

### 172. Trichoda Grandinella.

Trichoda ſphærica, pellucida, ſuperne crinata. Spherical, pellucid, the upper part hairy.

A moſt minute pellucid globule, the inteſtines ſcarce viſible, the top of it's ſurface furniſhed with two, three, or more ſhort briſtles, which are with difficulty ſeen, the animalculum extending,

and

and then withdrawing them in an inſtant. It is found in pure water, and in infuſions of vegetables.

### 173. Trichoda Cometa. Fig. 46 and 47, Plate XXV.

Trichoda ſphærica, antice crinita, globulo appendente. Spherical, the fore-part hairy, with an appendant globule.

It is a pellucid globule, replete with bright inteſtines, the fore-part furniſhed with hairs, the hind-part with a pellucid appendant globule.

### 174. Trichoda Granata. Fig. 48, Plate XXV.

Trichoda ſphærica, centro opaco, peripheria crinata. Spherical, with an opake center, the periphery hairy.

It reſembles the trichoda grandinella and trichoda cometa. It has a darkiſh nucleus in the center; it's inteſtines are imperceptible; ſhort hairs on the edge.

### 175. Trichoda Trochus.

Trichoda ſubpiriformis, pellucida, antice utrinque crinita. Trichoda ſomewhat of a pear-ſhape, pellucid, each ſide of the fore-part diſtinguiſhed by a little bunch of hairs.

### 176. Trichoda Cyrinus.

Trichoda ovalis teres cryſtallina, antice crinita. Oval, round, cryſtalline trichoda, the front hairy.

It is one of the ſmalleſt among the trichoda, the body ſmooth and free from hairs, except at the fore-part, where there are a few. Found in ſalt water.

### 177. Trichoda Sol. Fig. 65 and 66, Plate XXV.

Trichoda globularis, undique radiata. Globular trichoda, every-where radiated.

This ſplendid creature conſtitutes a new genus, but as we know of no more of the ſame kind, it is introduced here. It is a little cryſtalline round corpuſcle, the upper part convex; it is beſet with innumerable diverging rays, which are longer than the body, proceeding from every part of it's ſurface: in the inſide are ſimilar molecules. The body contracts and dilates itſelf, the animalculum remaining confined to the ſame ſpot. It was found in water in which there were other infuſoria, and which had been kept for three weeks. It propagates by diviſion, and is repreſented as dividing in Fig. 66.

### 178. Trichoda Solaris.

Trichoda ſphæroidea, peripheria crinita. Spheroidal trichoda, with a few hairs round the circumference.

The body is bright, orbicular, with globular viſcera in the middle of it; in many a moveable ſubſtance, ſomething like the letter S, may be diſcovered; it has ſeldom more than ſeventeen hairs, which are diſpoſed round the circumference; each of them is in length nearly equal to the diameter of the animalculum.

### 179. Trichoda Bomba. Fig. 67 and 68.

Trichoda mutabilis, antice pilis ſparſis. Changeable, with a few hairs diſperſed on the fore-part.

It is larger than the trichoda granata, and of a yellow colour; it is a thick animalculum, pellucid, and replete with a kind of clay molecules; it is very lively, moving about with ſo much velocity as to elude the ſharpeſt ſight and moſt pertinacious obſerver, ſometimes appearing ſpherical, ſometimes reniform, (kidney-ſhaped) ſometimes as at Fig. 67.

### 180. Trichoda Orbis.

Trichoda orbicularis, antice emarginata crinita. Orbicular, the fore-part notched and hairy.

It in ſome reſpects reſembles the former, but is larger; is orbicular, ſmooth, and pellucid, a little notched in the fore-part; the hairs, which are longer than uſual, occupy this inciſion, the reſt of the margin has no hairs; the whole is compoſed of veſicular molecules.

### 181. Trichoda Urnula. Fig. 64.

Trichoda urceolaris, antice crinita. This trichoda is in the form of a water pitcher, the fore-part hairy.

A membranaceous pellucid animalculum, the hind-part obtuſe, the middle ſomething broader, the fore-part truncated, filled with veſicular black molecules; the hairs in the fore-part are even and ſhort. It's motion is ſlow.

### 182. Trichoda Diota.

Trichoda urceolaris, antice anguſtata, ora apicis utrinque crinita. Pitcher-ſhaped trichoda, the fore-part ſmalleſt, each edge of the upper-part of the mouth hairy.

The body is of a clay colour, and filled with molecules; the lower part ſpherical, the upper part cylindrical and truncated.

### 183. Trichoda Horrida.

Trichoda ſubconica antice latiuſcula, truncata poſtice obtuſa; ſetis radiantibus cincta. Trichoda ſomewhat of a conical form, the fore-part rather broad and truncated, the lower part obtuſe, the body covered with radiating briſtles.

### 184. Trichoda Urinarium.

Trichoda ovata, roſtro breviſſimo crinito. Egg-ſhaped, with a ſhort hairy beak.

### 185. Trichoda Semiluna.

Trichoda ſemiorbicularis, antice ſubtus crinita. Semiorbicular, the fore-part hairy underneath.

A pellucid ſmooth animalculum, reſembling the figure of the moon in the firſt quarter.

### 186. Trichoda Trigona. Fig. 63.

Trichoda convexa, antice ciliata, poſtice eroſa. Convex, the fore-part ciliated, the hind-part as it were gnawed off.

This is a triangular animalculum, a little convex on both ſides, the fore-part acute, the hind-part a little broader. A notch is ſeen at a in the hind-part, b the ciliated fore-part, c a tube.

### 187. Trichoda Tinea.

Trichoda clavata, antice crinita, poſtice groſſa. This is clubbed, the fore-part hairy, the hind-part large.

This animalculum is round, not very pellucid, reſembling an inverted club, narrow before; it is alſo like ſome of the tinea.

### 188. Trichoda Nigra.

Trichoda ovalis compreſſa, antice latior crinita. Oval compreſſed trichoda, the fore-part broader and hairy.

The body is opake, when in violent motion it is black, when at reſt one ſide is pellucid; the middle of the fore-part is furniſhed with little moveable hairs. It was found in ſalt water.

### 189. Trichoda Pubes. Fig. 61 and 62.

Trichoda ovato-oblonga gibba, antice depreſſa. An egg-ſhaped oblong bunch, fore-part depreſſed.

An animalculum with a bunch above the hind-part, marked with black ſpots, depreſſed towards the top, a little folded, and ſomewhat convex underneath; at leaſt this is it's appearance when in motion. Very minute hairs occupy the apex, but which are with difficulty ſeen, except when it is in the agonies of death, it then ſtretches them out with all it's might from an arched chink at the top, moving them vehemently, and endeavouring as it were to draw in the laſt drop of water. Is found in water where the duck-weed grows, moſtly in December. b the hairs, c the black globules, a the projecting bunch.

### 190. Trichoda Floccus.

Trichoda membranacea, antice ſubconica, papillis tribus crinitis. Membranaceous trichoda, the fore-part rather conical, three ſmall papillæ project from the baſe, which are ſet with hairs.

### 191. Trichoda Sinuata.

Trichoda oblonga depreſſa, altero margine ſinuato crinita, poſtice obtuſa. An oblong depreſſed trichoda, one margin hollow and hairy, the lower end obtuſe.

The inteſtines ſeem to be more lymphatic than molecular; it is of a yellow colour, the hollow edge is that which is ciliated. It was found in river water.

### 192. Trichoda Præceps.

Trichoda membranacea, ſublunata, medio protuberante, extrorſum crinita. Membranaceous trichoda, ſomewhat lunated, protuberant in the middle, a row of hairs on the outſide.

A pellucid membrane, the fore-part formed into a kind of neck, one edge riſes into a protuberance like a hump back, the other edge is convex.

### 193. Trichoda Proteus. Fig. 56, 57, 58, 59, 60, Plate XXV.

Trichoda ovalis, poſtice obtuſa, collo elongata retractile, apice crinito. Oval trichoda, the lower part obtuſe, with a long neck, which it has a power of contracting or extending.

Baker's Empl. for Micr. p. 340, 348.

This is the ſame animalculum which was dignified by Mr. Baker with the name of proteus, on account of it's aſſuming a great number of different ſhapes, ſo as ſcarce to be known for the ſame animal in it's various transformations; and indeed, unleſs it be carefully watched while paſſing from one ſhape to another, it will often become ſuddenly inviſible.

When water, wherein any ſorts of vegetables have been infuſed, or animals preſerved, has ſtood quietly for ſome days, or weeks, in any glaſs or other veſſel, a ſlimy ſubſtance will be collected about the ſides, ſome whereof being taken up with the point of a penknife, placed on a ſlip of glaſs, in a drop of water, and looked at through the microſcope, will be found to harbour ſeveral kinds of little animals that are ſeldom ſeen ſwimming about at large. The inſect we are treating of is one of theſe, and was diſcovered in ſuch ſlime-like matter, taken from the ſide of a glaſs jar, in which ſmall fiſhes, water-ſnails, and other creatures had been kept. It's body in ſubſtance and colour reſembled a ſnail's; the ſhape thereof was ſomewhat elliptical, but pointed at one end, whilſt from the other a long, ſlender, and finely-proportioned neck ſtretched itſelf out, and was terminated with a head, of a ſize perfectly ſuitable to the other parts of the animal.

### 194. Trichoda Verſatilis.

Trichoda oblonga, poſtice acuminata, collo retractili, infra apicem crinito. Oblong trichoda, the hind-part acute, with a neck that it can extend or contract at pleaſure, the under part of the extremity of the neck hairy.

It reſembles in ſome meaſure the trichoda proteus, but the neck is ſhorter, and the apex leſs ſpherical, the hinder-part of the trunk acute. It lives in the ſea.

### 195. Trichoda Gibba. Fig. 55.

Trichoda oblonga, dorſo gibbera, ventre excavata, antice ciliata, extremitatibus obtuſis. Oblong trichoda, with a bunch on the back, the belly hollowed out, the fore-part ciliated, both ends obtuſe.

The body is pellucid, the upper-part ſwelled out, within it are numerous obſcure molecules, and three large globules, the ends rather incline downwards; when the water begins to fail, a few minute hairs may be diſcovered about the head, and at the abdomen; the body then becomes ſtriated longitudinally.

### 196. Trichoda Foeta.

Trichoda oblonga, dorſo protuberante, antice ciliata, extremitatibus obtuſis. Oblong trichoda, with the back protuberant, the fore-part ciliated, both ends obtuſe.

The body is round and long, and when extended reſembles a rolling-pin in ſhape, with the ends obtuſe, and one ſhorter than the other; it can draw in the ends, and ſwell out the ſides, ſo as to appear almoſt ſpherical.

### 197. Trichoda Patens. Fig. 54.

Trichoda elongata, teres, antice foveata, fovæ marginibus ciliata. This trichoda is long, round, in the fore-part it has a long hole, the edges of which are ciliated.

It is a long cylindrical animalculum, filled with molecules, the fore-part bright and clear, a long opening (a) near the top, which tapers to a point, and is beſet with hairs. It is found of different lengths in ſalt water.

### 198. Trichoda Patula.

Trichoda ventricoſa, ſubovata, antice canaliculata, apice & canaliculo crinito. Ventricoſe, rather inclining towards an oval figure, with a ſmall tube at the ſore-part, the upper end of the tube beſet with hairs.

### 199. Trichoda Foveata.

Trichoda oblonga, latiuſcula, antice corniculis micantibus, poſtice mutica. Oblong trichoda, rather broad, three little horns on the fore-part, the hinder-part beardleſs.

## 200. Trichoda Striata.

Trichoda oblonga, altero margine curſum, ſinuata et ciliata, utraque extremitate obtuſa. Oblong trichoda, one edge rather curved, and alſo furniſhed with a row of hairs, both extremities obtuſe.

It is a ſplendid animalculum, of a fox colour, and at firſt ſight might be taken for a kolpoda. The body is oblong, the lower end is the largeſt, the body becoming ſmaller at that part where the hairs commence; it has a ſet of ſtreaks which run from one end to the other, and at the abdomen a double row of little eggs, lying in a tranſverſe direction. It was found in river water in December.

## 201. Trichoda Uvula. Fig. 53.

Trichoda planiuſcula elongata, æqualis, antice crinita. Rather flat and long, of an equal ſize throughout, the fore-part hairy.

This animalculum is ſix times longer than it is broad, round, flexuous, of an equal ſize, the greater part filled with obſcure molecules, the fore-part (a) rather empty, diſtinguiſhed by an alimentary canal, and lucid globules near the middle c; ſhort hairs occupy the margin of the fore-part, ſome are diſperſed into a chink near the canal. Found in an infuſion of hay, &c.

### 202. Trichoda Aurantia.

Trichoda ſubſinuata, ovata, antice patula, apice ad medium crinita. Trichoda ſomewhat ſinuated, oval, the fore-part broad, the apex hairy to the middle.

It is of a gold colour, pellucid, and filled with a variety of veſicles.

### 203. Trichoda Ignita.

Trichoda ovata, apice acuminata, ſubtus ſulcata, ſulco crinito. Oval trichoda, the apex rather acute, the under part furrowed, the furrows hairy.

It is of a fine purple gold colour, ſomewhat of a reddiſh caſt, pellucid, ſplendid, with a number of different-ſized globules; the fore-part ſmall, the hind-part obtuſe, and having a very large opening, which runs as it were through the body.

### 204. Trichoda Priſma.

Trichoda ovata, ſubtus convexa, ſupra in carinam compreſſa, antice anguſtior. Oval trichoda, the under part convex, the upper part compreſſed into a kind of keel, the fore-part ſmall.

It is very ſmall, and ſo tranſparent, as not eaſily to be delineated; no hairs could be obſerved, and it's form is ſingular.

### 205. Trichoda Forceps.

Trichoda ovalis, antice forcipata, cruribus inæqualibus crinitis. Oval trichoda, with a pair of forceps at the fore-part, with unequal hairy legs.

A large animalculum, ſomewhat depreſſed, of a pellucid yellow colour, filled with molecules; in the lower part there is a black opake globule, the fore-part is divided into long lobes, one of theſe in the ſhape of a bill, (falciformis) and acute, the other is dilated, and obliquely truncated; both the apex and the edge of theſe are furniſhed with hairs of different lengths; it can open and ſhut theſe forceps, and croſs them at pleaſure; by this motion it ſucks in the water. It was found in water that was covered with lemna, about the winter ſolſtice.

### 206. Trichoda Forfex.

Trichoda ventroſa, antice forcipata, poſtice papilla duplici inſtructa. Ventroſe trichoda, the fore-part formed into a kind of forceps, and two ſmall protuberances.

One of the forceps of this animalculum is twice as long as the other, hooked, and ciliated. It was found in river water.

### 207. Trichoda Index.

Trichoda obovata, margine antico ſubtus crinito, alteroque apicis in degitum producto. Obovated trichoda, the under part of the ſront margin hairy, the apex is formed by the fore-part, projecting like the finger on a direction-poſt. It was found in ſalt water.

### 208. Trichoda S.

Trichoda ſtriata, antice ciliata, extremitatibus in oppoſitum flexis. Striated trichoda, the fore-part ciliated, the extremities bent in oppoſite directions.

A yellow animalculum, formed of two pellucid membranes, ſtriated longitudinally; the lower end is obliquely truncated.

### 209. Trichoda Navicula.

Trichoda triquetra, antice truncata ciliata, poſtice acuta prominula. Three-cornered trichoda, the fore-part truncated and ciliated, the hind-part acute, and bent a little upwards.

It is cryſtalline, rather broad, the under-ſide towards the hinder-part convex, the fore-part broad, the apex nearly a ſtrait line, the bent end pointed and turned upwards; it has a kind of longitudinal keel running down the middle.

### 210. Trichoda Succiſa.

Trichoda ovalis depreſſa, margine crinito, poſtice in crura inæqualia eroſa. Flattened oval trichoda, the edge hairy, the hinder-part hollowed out ſo as to form two unequal legs.

### 211. Trichoda Sulcata.

Trichoda ovato-ventricoſa, apice acuminata, ſulco ventrali, utrinque crinito. Ovated ventricoſe trichoda, the apex acute, a furrow at the abdomen, both ſides of it ciliated.

### 212. Trichoda Anas. Fig. 49.

Trichoda elongata, apice colli ſubtus crinito. Long, the apex of the neck underneath hairy.

A ſmooth animalculum, five times broader than it is long, filled with darkiſh molecules; a bright neck b c, under the top of the neck at d there ſhine a few unequal hairs. It's motions are languid. It is found in pure water.

### 213. Trichoda Barbata.

Trichoda elongata, teres, ſubtus ab apice ad medium crinita. Trichoda long, round, the under-part, from the apex to the middle, hairy.

This animalculum is round, ſomewhat linear, both ends obtuſe, the fore-part narrower, forming as it were a kind of neck; under this is a row of fluctuating hairs. The trunk is full of grey molecules.

### 214. Trichoda Farcimen. Fig. 50 and 52, Plate XXV.

Trichoda elongata, toruloſa, ſetulis cincta. Long and thick trichoda, ſurrounded with ſmall briſtles.

The body is long, round, pellucid, and covered with very minute hairs; it has alſo about the body a great number of mucid veſicles.

### 215. Trichoda Crinita.

Trichoda elongata, teres, undique ciliata, ſubtus ad medium uſque crinita. Long trichoda, round, every-where ciliated, the under-part alſo hairy as far as the middle.

### 216. Trichoda Angulus.

Trichoda angulata, apice crinita. Angular, the apex hairy.

This animalculum is long, more convex than moſt of it's kind, divided, by a kind of articulation, into two parts, of equal breadth, but differing in length, the fore-part ſhorter than the hind-part, the apex furniſhed with ſhort waving hair, indiſtinct molecules within-ſide, no hair on the hind-part.

### 217. Trichoda Linter. Fig. 51, Plate XXV.

Trichoda ovato oblonga, utraque extremitate prominula. The ſhape of an oblong egg, with prominencies at both extremities.

Both extremities of the body are raiſed, ſo as to be convex at bottom, the upper part depreſſed like a boat; ſometimes the whole body whirls about. It differs from itſelf at different ages. Is found in an infuſion of old graſs.

### 218. Trichoda Paxillus.

Trichoda linearis depreſſa, antice truncata crinitaque, poſtice obtuſa. Linear flat trichoda, the fore-part truncated and hairy, the hinder-part obtuſe.

A long animalculum, full of grey molecules, the fore-part rather ſmaller than the hind-part, and furniſhed with minute hairs. Was found in ſalt water.

### 219. Trichoda Vermicularis. Fig. 1, Plate XXVI.

Trichoda elongata, cylindracea, collo brevi, apice crinito. Long cylindrical trichoda, with a ſhort neck, the apex hairy.

Gelatinous, the fore-part pellucid, the hind-part full of molecules. It was found in river water. It is repreſented in different appearances in the figure, a the neck, b the hairs, c a little veſicle in the hinder-part.

### 220. Trichoda Melitea. Fig. 2, Plate XXVI.

Trichoda oblonga, ciliata, colli dilatabilis, apice globoſo, pilifero. Oblong ciliated trichoda, with a dilatable neck, the apex globular, and ſurrounded with hairs, the edge is ciliated, and a kind of periſtaltic motion may be perceived. It is very rarely found, and even then in ſalt water. a the neck, b the globular apex, c the body ciliated.

### 222. Trichoda Fimbriata. Fig. 2, Plate XXVI.

Trichoda obovata, apice crinita, poſtice oblique truncata ſerrata. Obovated trichoda, the apex hairy, the hinder-part obliquely truncated and ſerrated.

### 223. Trichoda Camelus.

Trichoda antice crinita, craſſiuſcula medio utrinque emarginata. Thick, and the fore-part hairy, with notches on the middle and each ſide.

The fore-part of the body is ventricoſe; the back is divided, by an inciſion in the middle, into two tubercles, the lower part of the belly ſinuated. Languid in it's motion. Is found, though not often, in infuſions of vegetables.

### 224. Trichoda Augur.

Trichoda oblonga, vertice truncata, antico corporis margine, ſuperne pedata, inferne ſetoſa. The body oblong, depreſſed, pellucid, and filled with molecules; the vertex truncated, the fore-part forming a ſmall beak, underneath are three feet; beyond theſe, towards the hinder-part, it is furniſhed with briſtles.

### 225. Trichoda Pupa.

Trichoda cucullata, fronte crinita, cauda inflexa. This trichoda is hooded, the front hairy, the tail inflected.

At firſt ſight it reſembles the pupa of the gnat. The body is rather round, pellucid, and may be deſcribed as conſiſting of three parts; the head, which is broad, and as it were hooded, the top furniſhed with very ſmall hairs, a tranſparent veſicle occupies the lower region of the head, and a certain production hangs over the breaſt from the baſe of the head, reſembling the ſheath of the feet in the pupa of the gnat.

### 226. Trichoda Lunaris.

Trichoda arcuata, teres, apice crinita, cirro caudali inflexo. Arched trichoda, round, the apex hairy, the tail bent.

This animalculum bends itſelf in the form of an arch, is round and cryſtalline, the hind-part ſomewhat ſmaller than the fore-part; the inteſtines are with difficulty diſtinguiſhed. The edge of the back, and the part near the tail, are bright and clear.

### 227. Trichoda Bilunis.

Trichoda arcuata, depreſſa, apice crinita, cauda biſeta. Arched flattened trichoda, the apex hairy, two little briſtles proceeding from the tail.

### 228. Trichoda Rattus. Fig. 4, Plate XXVI.

Trichoda oblonga, carinata, antice crinita; poſtice ſeta longiſſima. Oblong trichoda, with a kind of keel, the fore-part hairy, a very long briſtle proceeding from the hinder-part. a the mouth, b a ſmall knob at the bending of the tail, c the tail.

### 229. Trichoda Tigris.

Trichoda ſubcylindrica, elongata, apice crinita, cauda ſetis duabus longis. This trichoda is long, and ſomewhat cylindrical, the apex hairy, the tail divided into two long briſtles.

It differs from the preceding in two particulars; firſt, that of the tail; ſecond, in a kind of inciſion in the body, at ſome little diſtance from the apex.

### 230. Trichoda Pocillum. Fig. 5 and 6, Plate XXVI.

Trichoda oblonga, antice truncata, crinita, cauda articulata, biſeta. Oblong trichoda, the fore-part truncated and hairy, the tail articulated, and divided into two briſtles.

The body is cylindrical, pellucid, muſcular, capable of being folded up, ſeems as if it were formed of two; the interior one, which is filled with molecules, has alſo an orbicular muſcular appendage, which it can ſhut and open, and that forms the mouth. The exterior one is membranaceous, dilated, pellucid, and marked with tranſverſe ſtreaks; the animalculum can protrude or draw in the orbicular membrane at pleaſure. In ſome there are four articulations to the tail, in others five; it has two pair of briſtles, or projecting parts, one placed at the ſecond joint, the other at the laſt. It has been found very often in marſhy waters. In Fig. 6 it is ſeen with the mouth open, in Fig. 5 with it ſhut, a the jaws, b the firſt briſtles, c the ſecond pair, d the ſpine at the tail.

### 231. Trichoda Clavus.

Trichoda antice rotundata, crinita poſtice acuminato-caudata. The fore-part round and hairy, the hind-part furniſhed with a ſharp-tail. This animalculum is not much unlike in ſhape to a common nail.

### 232. Trichoda Cornuta.

Trichoda ſupra convexa, ſubtus plana, apice crinita, cauda lineari ſimplici. Trichoda with the upper part convex, the under ſide plain, the apex hairy, the tail linear and ſimple.

To theſe characters we may add, that the body is membranaceous, elliptical, crammed with molecules, the fore-part lunated, the hinder-part round, and terminated with a tail as long as the body.

### 233. Trichoda Gallina.

Trichoda elongata, antice ſinuata, fronte crinita, cauda piloſa. Long trichoda, the fore-part ſinuated, the front hairy, the tail formed of ſmall hairs.

The body flat, of a grey colour, with ſeven large molecules and globules within it, the front obtuſe, and ſet with hairs, the hinder-part terminating in a tail, which is formed of very fine hairs. It was found in river water.

### 234. Trichoda Muſculus. Fig. 7, Plate XXVI.

Trichoda ovalis antice crinita, poſtice ſubtus caudata. Egg-ſhaped, the fore-part hairy, the tail projecting from the under-part.

A ſmooth egg-ſhaped animalculum, with a double margin, or line, drawn underneath it, the fore-part narrow, and furniſhed with ſhort hairs that are continually playing about; underneath the hind-part is a ſmall tail. It is furniſhed with molecular entrails, and moves ſlowly. Is found in infuſions of hay, which have been kept for ſome months. a the head, b the tail.

### 235. Trichoda Delphis.

Trichoda clavata, fronte crinita, cauda acuminata, ſubreflexa. Clubbed trichoda, the front hairy, the tail ſmall, and rather bent upwards.

It is ſmooth and pellucid, the fore-part dilated into a ſemicircle, decreaſing in breadth towards the tail; the hairs ſtand as rays from the ſemicircular edge at the front, one edge is ſometimes contracted. It is to be found in river water.

### 236. Trichoda Delphinus. Fig. 8, Plate XXVI.

Trichoda oblonga, antice crinita, poſtice cauda reflexa truncata. Oblong, the fore-part hairy, in the hind-part is the tail, which is turned back, the end of it truncated.

A pellucid, ſmooth, egg-ſhaped animalculum; the hind-part is produced into a tail about half the length of the body, dilated at the upper end, and truncated; it is always bent upwards.

In the inſide are veſicles of an unequal ſize; it ſometimes moves on it's belly, ſometimes on one ſide; the tail ſeldom varies in it's poſition. Was found in hay that had been infuſed for ſome months. a the hairs on the fore-part, b the tail.

### 237. Trichoda Clava.

Trichoda clavata, fronte crinita, cauda reflexili. The club trichoda, the fore-part hairy, the tail turned back.

The fore-part is thick, the hind-part narrow, both extremities obtuſe, pellucid and replete with molecules, the hind-part bent downwards towards the middle.

### 238. Trichoda Cuniculus.

Trichoda oblonga, antice crinita, poſtice ſubacuminata. Oblong, the fore-part hairy, the hind-part rather acute, filled with molecules and black veſicles.

### 239. Trichoda Felis. Fig. 9, Plate XXVI.

Trichoda curvata, groſſa, antice anguſtior, poſtice in caudam attenuata, ſubtus longitudinaliter crinita. Curved trichoda, large, the fore-part ſmall, the hinder-part gradually diminiſhed ſo as to form a tail, the under-ſide beſet longitudinally with hairs. a the head, b the tail, c the hairs.

### 240. Trichoda Piſcis. Fig. 13 and 14, Plate XXVI.

Trichoda oblongata, antice crinita, poſtice in caudam exquiſitam attenuata. Oblong, the fore-part hairy, the hind-part terminating in a very ſlender tail. Smooth and pellucid, much longer than it is broad, but of nearly an equal breadth throughout, filled with yellow molecules, the fore-part obtuſe, the hind-part exquiſitely ſlender and tranſparent, the upper ſide is convex. a the fore-part, b the tail.

### 241. Trichoda Larus.

Trichoda elongata, teres, crinita, cuſpidi caudali duplici. Long round trichoda, beſet with hairs, the tail divided into two points. See Zoologia Danica.

### 242. Trichoda Longicauda. Fig. 10, Plate XXVI.

Trichoda cylindracea, antice truncata et crinita, cauda elongata, biarticulata & biſeta. Cylindrical trichoda, the fore-part truncated and ſet with hairs, the tail long, with two joints, and terminated by two briſtles. a the hairs at the mouth, d the oeſophagus, c the articulation of the tail, f the briſtles.

### 243. Trichoda Fixa.

Trichoda ſphærica, peripheria crinita, pedicello ſolitario. Spherical trichoda, the circumference ſet with hairs, and a little ſolitary pedicle projecting from the body.

### 244. Trichoda Inquilinus.

Trichoda vaginata, folliculo cylindrico hyalino, pedicello intra folliculum retortili. Sheathed trichoda, in a cylindrical tranſparent bag, and a little pedicle bent back within the bag. See Zool. Dan. prodr. addend. p. 281.

### 245. Trichoda Ingenita.

Trichoda vaginata, folliculo depreſſa, baſi latiore ſeſſilis. Sheathed trichoda, the bag depreſſed, the baſe broadeſt.

The animalculum that is contained in this ſheath is funnel-ſhaped; a hair, or hairs, may be perceived on each ſide of the mouth of the funnel. It can extend or contract itſelf freely in the bag, without even touching the ſides, the tail reſting on the baſe thereof. It was found in ſalt water.

### 246. Trichoda Innata. Fig. 11, Plate XXVI.

Trichoda vaginata, ſolliculo cylindrico, pedicello extra folliculum. Sheathed trichoda, with a cylindrical bag, the pedicle paſſing through and projecting beyond the bag. Theſe characters diſtinguiſh it ſufficiently from the preceding one. b the animalculum in the ſheath, d the tail.

### 247. Trichoda Transfuga.

Trichoda latiuſcula, antice crinita, poſtice ſetoſa, altero latere ſinuata, altero mucronata. Broad trichoda, the fore-part hairy, the hinder-part full of briſtles, one ſide ſinuated, the other pointed. See Zool. Dan. prod. addend. p. 281.

### 248. Trichoda Ciliata.

Trichoda ventricoſa, poſtice crinibus pectinata. See Zool. Dan. Icon. tab. 73, Fig. 13, 15.

### 249. Trichoda Bulla.

Trichoda membranacea, lateribus inflexis, antice & poſtice crinita. Membranaceous trichoda, the ſides bent inwards, the fore and hind-part are both furniſhed with hairs; it differs only by the laſt circumſtance from the burſaria bulla.

### 250. Trichoda Pellionella.

Trichoda cylindracea, antice crinita, poſtice ſetoſa. Cylindrical, the fore-part hairy, the hinder-part furniſhed with briſtles.

This trichoda is rather thick in the middle, pellucid, with a few molecules here and there, the ſides obtuſe, the fore-part ciliated, the hairs very fine, the hind-part terminating in a kind of briſtles.

### 251. Trichoda Cyllidium. Fig. 15, Plate XXVI.

Trichoda ovata, apice hiante, baſique crinita. Egg-ſhaped, the apex gaping, the baſe hairy.

Pellucid, replete with globules of different ſizes, in the hind-extremity; the fore-part narrower, without any footſteps of an external organ. It vacillates upon the edge, commonly advancing on it's flat ſide, continually drawing up water; it then gapes, opens into a very acute angle, almoſt to the middle of the body. It is difficult to be perceived, as it effects this in an inſtant. a the mouth, b the hairs or briſtles, which it extends when in agonies.

### 252. Trichoda Curſor.

Trichoda ovata, antice crinita, poſtice duplici pilorum ſtrictorum & curvorum faſciculo. Oval trichoda, the fore-part hairy, the hinder-part furniſhed with two faſcicles of ſtrait and curved hairs.

The body flat, and filled with molecules; in the fore-part there is an oblong empty ſpace, into which, under certain circumſtances, we may ſee the water as it were ſucked in.

### 253. Trichoda Pulex. Fig. 12, Plate XXVI.

Trichoda ovata, antice inciſa, fronte & baſi crinita. Egg-ſhaped, with an inciſion in the fore-part, the front and the baſe hairy. a the anterior, b the poſterior part, c the inciſion.

### 254. Trichoda Lynceus. Fig. 16, Plate XXVI.

Trichoda ſubquadrata, roſtro adunco, ore crinito. Nearly ſquare, with a crooked beak, the mouth hairy.

At firſt ſight it does not appear very diſſimilar to ſome of the monoculi. The body is membranaceous, and as it were compreſſed, being broad without thickneſs, ſtretched out into a beak above, the lower part truncated; under the beak is a little bundle of hairs, the lower edge bends in and out, and is girt round with a few briſtles. The inteſtines are beautifully viſible, a ſmall bent tube goes from the mouth to the inteſtines in the middle of the body; theſe, as well as the tube, are in frequent agitation; another tube is alſo perceivable between the fore and hind edge. It is filled with a blue liquor. a the beak, b the mouth, c the baſe.

### 255. Trichoda Eroſa.

Trichoda orbicularis, antice emarginata, altero latere crinita, poſtice ſetoſa. Orbicular trichoda, the fore-part notched, one ſide ſet with hairs, the hinder-part with briſtles.

### 256. Trichoda Roſtrata.

Trichoda depreſſa, mutabilis, flaveſcens, ciliis longis ſetiſque pediformibus. Depreſſed trichoda, mutable, yellow, with long ciliated hairs, and feet tapering to a point.

The body depreſſed, both the feet and hairs are within the margin, the feet are four in number, one of them is longer than the reſt. The figure of the body is for the moſt part ſomewhat triangular, the apex formed into a kind of obtuſe beak; the beak is ſometimes drawn in ſo that the animalculum then appears altogether orbicular. Found in water where duck-weed has been kept.

### 257. Trichoda Lagena.

Trichoda teres, ventricoſa, roſtro producta, poſtice ſetoſa. Round ventricoſe trichoda, with a long neck, the lower end ſet with briſtles.

### 258. Trichoda Charon. Fig. 17 and 18, Plate XXVI.

Trichoda cymbiformis ſulcata, antice et poſtice crinita. Boat-ſhaped trichoda with furrows, the fore and hind-parts both hairy.

The body is oval; it reſembles a boat both in ſhape and motion, the upper part hollowed, the under part furrowed and convex, the ſtern round, with ſeveral hairs projecting from it. Several hairs may alſo be ſeen on one ſide. Was found in ſalt water. a the head, b the tail; d, Fig. 18, a pellucid bubble that is ſometimes to be perceived.

### 259. Trichoda Cimex. Fig. 19, Plate XXXI.

Trichoda ovalis, marginibus lucidis, antice et poſtice crinita. Oval trichoda, with a lucid margin, both the fore and hind-part hairy.

It is about the ſize of the trichoda lynceus, an oval body, the back convex, the belly flat, an inciſion in the edge of the fore-part; the edges of this inciſion are ſeen to move. It's inteſtines are pellucid and ill-defined.

It both ſwims and walks. When it meets with any obſtacles, four ſmall briſtles, which are fixed underneath, come into view; theſe it uſes as feet. a the hairs in the fore-part, b the briſtles at the hind-part, d the back, e two ſmall projecting hairs.

### 260. Trichoda Cicada.

Trichoda ovalis, marginibus obſcuris, antice & ſubtus crinita, poſtice mutica. Oval trichoda, with an obſcure margin, the fore-part underneath ſet with hairs, the hinder-parts beardleſs.

It does not differ conſiderably from the preceding, though M. Muller has pointed out ſome ſhades by which they may be diſcriminated.

## XIV. KERONA.

Vermis inconſpicuus corniculatus. An inviſible worm with horns.

### 261. Kerona Raſtellum.

Kerona orbicularis membranacea, naſuta, corniculis in tota pagina. Membranaceous orbicular kerona, with one projecting point, the upper ſurface covered with ſmall horns. There are three rows of horns on the back, which nearly occupy the whole of it. It was found in river water.

### 262. Kerona Lyncaſter.

Kerona ſubquadrata. roſtro obtuſo, diſco corniculis micantibus. This ſpecies of kerona is rather ſquare, the diſc furniſhed with ſhining horns. See Zool. Dan. prod. add. p. 281.

### 263. Kerona Hiſtrio. Fig. 20, Plate XXVI.

Kerona oblonga, antice punctis mucronatis nigris, poſtice pinnulis longitudinalibus, inſtructa.

It is an oblong membrane, pellucid, with four or five black points in the fore-part, which are continually changing their ſituation, thick ſet with ſmall globules in the middle, among which four larger ones are ſometimes perceived, theſe are probably eggs; in the middle ſpace of the hind-part are ſome longitudinal ſtrokes reſembling briſtles; they do not ſeem to project beyond the body. b the horns, c ſome hairs, d a ſolitary horn, e a large globule, f ſome briſtles.

### 264. Kerona Cypris. Fig. 21, Plate XXVI.

Trichoda obovata, verſus poſtica ſuperne ſinuata, antice crinita. Egg-ſhaped, towards the hind-part ſinuated, the fore-part hairy.

This animalculum is compreſſed, and ſomething in a pear-ſhape, the fore-part broad and blunt, the front is furniſhed with ſhort hairs a, or little vibrating points inſerted under the edge, ſhorter in the hind-part, partly extended ſtrait, partly bent down; the motion is retrograde. It is found in water which is covered with lemna.

### 265. Kerona Hauſtrum.

Kerona orbiculata, corniculis mediis, antice membranacea ciliata, poſtice ſetoſa. Orbicular kerona, the horns in the middle, the fore-part membranaceous and ciliated, at the hinder-part there are ſeveral briſtles.

### 266. Kerona Hauſtellum.

Differs from the preceding only in having the hinder-part without any briſtles.

### 267. Kerona Patella. Fig. 22 and 23, Plate XXVI.

Kerona univalvis, antice emarginata corniculata, poſtice ſetis flexilibus pendulis. With one valve, orbicular, cryſtalline, the fore-part ſomewhat notched, the fleſhy body lies in the middle of the ſhell; above and below are hairs, or horns, of different lengths, jutting out beyond the ſhell, and acting inſtead of feet and oars, ſome of which are bent; the ſuperior ones conſtitute a double tranſverſe row. a the fore-part, b the horns, d a lunated figure in the ſhell, c a pulpous body, f briſtles at the hinder-part.

### 268. Kerona Vannus.

Kerona ovalis, ſubdepreſſa, margine altero flexo, oppoſito ciliato, corniculis anticis, ſetiſque poſticis. Oval and rather flat kerona, one edge bent, the oppoſite edge ciliated, the front furniſhed with horns, the hinder-part with briſtles.

### 269. Kerona Pullaſter. Fig. 24 and 25, Plate XXVI.

Kerona ovata, antice ſinuata, fronte creſtata, baſi crinita. Oval, the fore-part ſinuated, a creſt on the front, the baſe hairy.

It agrees with the trichoda pulex in many particulars, but the upper part is pellucid, without any black molecules, the front truncated, the whole ſuperficies of the head covered with hair, and the fore-part ſinuous. a the horns, b the hairs at the hinder-part, c the cilia of the front.

### 270. Kerona Mytillus. Fig. 29, Plate XXVI.

Kerona ſubclavata, utraque extremitate latiori, hyalina ciliata. Rather clubbed, broad at both extremities, clear and ciliated.

A large animalculum, the fore and hind-part rounded, very pellucid and white, dark in the middle, with black inteſtines, intermixed with a few pellucid veſicles. Both extremities ſeem as it were compoſed of two thin plates. The fore-part is ciliated, the hairs ſhort, lying within the margin; it is alſo ornamented with two little horns, erected from an obſcure maſs; with theſe it agitates the water, forming a little whirlpool. The hind-part is ciliated, and furniſhed with two briſtles, that ſtretch out beyond the margin. a the horns, b the fore-part ciliated, c the hind-part, d projecting briſtles.

### 271. Kerona Lepus.

Kerona ovata, apice crinito, baſi ſetoſa. Egg-ſhaped, the fore-part hairy, the baſe furniſhed with briſtles.

The body is egg-ſhaped, compreſſed, pellucid, crowned with ſhort waving hairs, the baſe terminating with briſtles.

### 272. Kerona Silurus.

Kerona oblonga, antice & poſtice crinita, dorſo ciliato. Oblong, the fore and hind-part hairy, the back ciliated.

An oval ſmooth animalculum, ſomething crooked and opake, a faſcicle of vibrating hair on the fore-part; the hind-part, or ſharp tail, furniſhed with unequal moveable rows of hairs, the back is alſo ciliated; theſe hairs produce a rotatory motion, in the inſide are ſome unequal, lucid, opake points. The figure varies from oval to oblong, the filaments of the conferva are often entangled in the tail.

### 273. Kerona Calvitium.

Kerona latiuſcula, oblonga, antice corniculis micantibus. Rather broad, oblong, with glittering horns on the fore-part.

The body is rather broad and flat, both ſides obtuſe, filled with black molecules, and more particularly a dark ſpot near the hinder-part; the interjacent veſicles are pellucid, no hairs on the fore-part, but inſtead thereof two little moveable horns, and from three to five moveable black points, a few ſhort briſtles at the hind-part. Found in the infuſions of vegetables.

### 274. Kerona Puſtulluata.

Kerona ovalis convexa, poſtice altero margine ſinuata, utraque extremitate crinita, corniculiſque anticis. Oval convex kerona, one edge of the hinder-part ſinuated, both ends ſet with hairs, and ſome horns placed on the fore-part.

This animalculum was found in ſalt water.

## XV. HIMANTOPUS.

Vermis inconſpicuus, pellucidus, cirratus. A pellucid, inviſible, cirrated * worm.

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* That is, furniſhed with a tuft or lock of hair.

### 275. Himantopus Acarus. Fig. 27, Plate XXVI.

Himantopus ventroſus, poſtice cirratus, antice acuminatus. Ventroſe himantopus, the hinder-part cirrated, the fore-part ſharp.

It is a lively, conical, ventricoſe animalculum, full of black molecules, the fore-part bright and tranſparent. The apex is more or leſs attenuated, at the will of the little creature, with rows of long hairs, like ſo many rays underneath; four locks of hair, or feet, long and crooked, proceed from the belly; it is continually moving theſe and the other hairs in various directions, it has the ſame circular motion in the ſame place. It is found, though ſeldom, where there is lemna. a the apex, b the ciliated part, c the feet.

### 276. Himantopus Ludio. Fig. 26, Plate XXVI.

Himantopus cirrata, ſupra crinita; cauda ſurſum extenſa. Curled himantopus, the upper part hairy, the tail extended upwards.

This is a lively and diverting animalculum, ſmooth, pellucid, full of little points, the fore-part clubbed, and a little bent, the hind-part narrow, the baſe obliquely truncated, terminating in a tail ſtretched out tranſverſely. The top of the head, and the middle of the back b, furniſhed with long vibrating hairs; from the ſide of the head hang three moveable and flexible curls a, diſtant from each other. When the animalculum is in motion, the tail is drawn tight, and extended upwards, and often appears as if it was cleft. It is curled up when the little creature is at reſt.

### 277. Himantopus Sannio.

Himantopus incurvata, ſupra ciliata, infra crinita. Crooked himantopus, the upper part ciliated, the under part hairy.

It is very much like the himantopus ludio, the cilia are longer than the hairs, and are continually vibrating; it has alſo two moveable curls hanging on both ſides the head. Is found but ſeldom, and then generally in water where the lemna vegetates.

### 279. Himantopus Volutator.

Himantopus lunatus, antice cirratus. Lunated himantopus, the fore-part hairy.

A very lively animalculum, of the ſhape of a creſcent, with ſome viſible cryſtalline points, the convex part furniſhed with a row of hairs, which are longeſt towards the tail; underneath are four feet. It often turns round ſwiftly in a circular direction.

### 280. Himantopus Larva.

Himantopus elongatus, medio cirratus. Long himantopus, cirrated in the middle.

By it's motion it reſembles the himantopus ludio, but differs from it in figure and ſituation of the parts. The body is rather depreſſed and long, the hinder parts acute, and generally curved, pellucid, filled with granular molecules.

### 281. Himantopus Charon.

Himantopus cymbæformis ſulcata, in fovea ventrali cirrata. Boat-ſhaped furrowed himantopus, the hollow part of the belly cirrated.

An oval pellucid membrane, the fore-part hairy, furrowed longitudinally, each ſide bent up ſo as to form an intermediate hollow place, or belly, crammed with grey molecules; beneath the middle it has ſeveral bent diverging rows of hairs; no hairs on the hinder-part. Rarely to be found, and then in ſea-water.

### 282. Himantopus Corona.

Himantopus ſemiorbiculata, depreſſa, in utraque pagina cirrata. Semiorbicular himantopus, flattened, both ſides cirrated.

A membranaceous lamina, very thin, very pellucid, cryſtalline, ſemilunar; the edge of the baſe thick ſet with molecular inteſtines, the other angle, or fore-part, furniſhed with ſhort hairs, or a kind of mane; towards the hind part three equal curved hairs, or ſpines.

## XVI. VORTICELLA.

Vermis contractilis, nudus, ciliis rotatoriis. A worm capable of contracting or extending itſelf, naked, with rotatory cilia.

### 283. Vorticella Viridis. Fig. 31, Plate XXVI.

Vorticella cylindracea, uniformis, viridis opaca. Cylindrical, uniform, green, and opake.

To the naked eye it appears as a ſmall green point, through the microſcope as an opake corpuſcle, of a dark-green colour, cylindrical, obtuſe at both extremities, yet rather thicker in the fore-part a; very ſimple, deſtitute of limbs, not changing it's figure. Notwithſtanding it's ſimplicity, the continual motion into which it puts the water gives room to ſuſpect that it is furniſhed with an inviſible rotatory inſtrument, it moves ſometimes circularly, ſometimes in a ſtrait line. a the fore-part, b the hind-part, c ſhort hairs.

### 284. Vorticella Sphæroida.

Vorticella cylindrico-globoſa, uniformis, opaca. A globous cylinder, uniform and opake.

To the naked eye it appears little more than a point ſwimming about in the water; but with the microſcope as a globular maſs, of a dark-green colour; they occaſion a vehement motion in the adjacent water, very ſhort hairs, which are probably the cauſe thereof, may be perceived.

### 285. Vorticella Cincta. Fig. 30, Plate XXVI.

Vorticella trapeziformis, nigro-viridis, opaca. This vorticella is in the form of a trapezium, of a blackiſh green colour, and opake.

It is of an irregular figure, inviſible to the naked eye, ciliated on every ſide, the hairs all moveable, and longer on one ſide than on the other. It ſometimes aſſumes an oval ſhape, and appears girt round with a tranſverſal keel.

### 286. Vorticella Lunifera.

Vorticella viridis, poſtice lunata, medio margine mucronato. Green vorticella, the hinder-part lunated, with a point in the middle, projecting from the edge.

The fore-part obtuſe, the baſe broad, and hollowed away like a creſcent, with a protuberance in the middle of the concave part, ſhorter than the horns or points of the creſcent; the fore-part is ciliated. It is found in ſalt water.

### 287. Vorticella Burſata. Fig. 32, Plate XXVI.

Vorticella viridis, apertura truncata, papillaque centrali. Green vorticella, the aperture truncated, with a central papillary projection.

Ventricoſe, crammed with molecules, the fore-part truncated, and both ſides of it, c c, pellucid; in the center of the aperture there is a prominent papilla or nipple b, which, when the animalculum is at reſt, appears notched; the edge a a of the aperture is ſurrounded with cilia; theſe are ſometimes all erected, ſhining, and in motion, or part bent back and quieſcent, and part in motion; ſometimes a few of them are collected together, and turned back like little hooks, one on each ſide. Found in ſalt water. a the cilia, b the projecting papilla, c the pellucid ſpace at the fore-part.

### 288. Vorticella Varia.

Vorticella cylindrica, truncata, opaca, nigricans. Cylindrical, truncated, opake, blackiſh-coloured vorticella, the fore-part ciliated.

### 289. Vorticella Sputarium.

Vorticella ventroſa, apertura orbiculari, ciliis longis raris excentricis. Ventroſe vorticella, with an orbicular aperture, and long hairs radiating as from a center.

This is a ſingular animalculum, even among thoſe where all are ſingular; viewed ſideways it is ſometimes cylindrical, though ſomewhat tapering towards the hinder-part, with a broad pellucid edge; viewed from the top it has ſometimes a broad face, or diſc, furniſhed with radiating hairs, the under part contracted into a globular ſhape, of a dark-green colour, and filled with ſmall grains. It was found in October with the leſſer lemna.

290. Vorticella Polymorpha. Fig. 33, 34, 35, Plate XXVI.

Vorticella multiformis, viridis, opaca. Many-ſhaped vorticella, green, opake.

To the naked eye it appears as a moſt agile green point; when viewed by the microſcope, it puts on every moment ſo many and ſuch various forms, that they can neither be exhibited to the eye by drawings, nor deſcribed by words; it is truly one of the wonders of nature, aſtoniſhing the mind, fatiguing the eye, and continually exciting the ſpectator to aſk,

"Quo teneam vultus mutantem protea nodo?"

Fig. 33, 34, 35, repreſent it in three different forms; a the fore-part, g the hind-part, c the fore-part ſimple, d the fore-part turned in or doubled, the body is granulous, a ſeries of pellucid points is ſometimes to be obſerved.

### 291. Vorticella Multiformis.

Vorticella viridis, opaca, varia, veſiculis ſparſis. Green, opake, variable vorticella, with veſicles ſcattered about the body.

This is ſo like the preceding one, that it needs no further deſcription. Is found in ſalt water, and the veſicles are larger.

### 292. Vorticella Nigra. Fig. 36 and 37, Plate XXVI.

Vorticella trochiformis nigra. Top-ſhaped black vorticella.

To the naked eye they preſent themſelves as ſmall black points ſwimming on the water; through the microſcope it appears as a little conical corpuſcle, opake, obtuſe, and ventricoſe at one extremity, the other acute; when it extends the extremities, two little white hooks come into ſight, by their aſſiſtance it moves in the water, and it is probable, from ſome circumſtances, that they incloſe a rotatory organ. It is in continual motion, vacillating on the top of the water. Is found in Auguſt, in meadows that are covered with water. a the rotatory organ, b the two ſmall hooks, c the acute end.

### 293. Vorticella Cucullus.

Vorticella elongata, teres, apertura oblique truncata. This vorticella is long, round, the aperture or mouth obliquely truncated.

This vorticella may be ranked among the larger ones, as it is viſible to the naked eye. The body is ſomewhat conical, of a dirty red colour; it's ſhape has been compared to that of a grenadier's cap.

### 294. Vorticella Utriculata.

Vorticella viridis, ventricoſa, productilis, antice truncata. Green vorticella, ventricoſe, the belly capable of being lengthened or ſhortened, the fore-part truncated, much in the ſhape of a common water-bottle, the neck ſometimes very long, at others with ſcarce any at all, and is filled with green molecules.

### 295. Vorticella Ocreata.

Vorticella ſubcubica, infra in angulum obtuſum producta. This vorticella is ſomewhat of a cubical figure, the under part bent in an obtuſe angle.

It is a very ſingular animalculum, being in ſhape like the lower part of a boot: the apex of the upper part, or leg, is truncated and ciliated, the heel pointed, the foot round. It is an inhabitant of rivers, though very rarely to be met with.

### 296. Vorticella Valga.

Vorticella cubica, infra divaricata. Cubical vorticella, the lower part divaricated.

This is filled with grey molecules, and is as broad as it is long, the apex truncated and ciliated, both angles of the baſe projecting outwards, one ſomewhat like a wart, the other like a finger. Found in marſhy waters.

### 297. Vorticella Papillaris.

Vorticella ventricoſa, antice truncata, papilla caudali & laterali hyalina. Ventricoſe vorticella, the fore-part truncated, a papillary tail, and a ſplendid papillary excreſcence on the ſide. Is an inhabitant of marſhes, where the conferva nitida is met with.

### 298. Vorticella Sacculus.

Vorticella cylindracea, apertura repanda, margine reflexo. Cylindrical vorticella, the aperture broad and flat, the edge turned down.

A thick animalculum, every-where of an equal diameter, and filled with molecules; the edge of the mouth bent back, the hinder-part obtuſe, ſometimes notched and contracted, cilia to be ſeen on both ſides the mouth.

### 299. Vorticella Cirrata.

Vorticella ventroſa, apertura ſinuata, cirro utrinque ventrali. Ventroſe vorticella, the aperture ſinuated, two tufts of hair on each ſide of the belly. It is an inhabitant of the water in ditches.

### 300. Vorticella Naſuta. Fig. 38, 39, Plate XXVI.

Vorticella cylindracea, crateris medio mucrone prominente. Cylindrical, with a prominent point in the middle of the cup.

An animalculum that is inviſible to the naked eye; but when it is armed with microſcopic lenſes, it appears curiouſly furniſhed with a rotatory organ, which encompaſſes the middle of the body.

It is pellucid, cylindrical, of an unequal ſize, the fore-part (a) truncated and ciliated, and a triangular prominency (e) in the middle of the aperture; the hind-part obtuſe, a point on each ſide of the middle of the body. This is the appearance of this little creature when in motion; but when the water is nearly exhaled, ſome further parts of it's ſtructure are rendered viſible; beſides the rotatory organ in the anterior part, another is now diſcovered encompaſſing the middle of the body; the hairs of this are in vehement motion. There are other faſcicles of moving hairs to be diſcovered at the ſame time. The variegated and quick motion of this apparatus (more particularly if the animalculum is big with young, and moving at the ſame time within the mother,) fill the mind with amazement.

### 301. Vorticella Stellina.

Vorticella orbicularis, diſco moleculari, peripheria ciliata. Orbicular vorticella, with a molecular diſc, and ciliated periphery.

### 302. Vorticella Diſcina. Fig. 8, 9, 10, Plate XXVI. A.

Vorticella orbicularis, margine ciliato, ſubtus convexo-anſata. Orbicular vorticella, the edge ciliated, with a kind of convex handle on the under ſide.

### 303. Vorticella Scyphina.

Vorticella craterformis, cryſtallina, medio ſphærula opaca. Bowl-ſhaped vorticella, cryſtalline, an opake ſpherule in the middle.

### 304. Vorticella Albina.

Vorticella cylindrica, poſtice acuminata. Cylindrical vorticella, the hinder-part tapering, and almoſt brought to a point.

### 305. Vorticella Fritillina.

Vorticella cylindrica vacua, apice truncata, ciliis prælongis. Empty cylindrical vorticella, the apex truncated.

### 306. Vorticella Truncatella.

Vorticella cylindrica, differta, apice truncata, ciliis breviuſculis. Cylindrical vorticella, ſtuffed or filled, the apex truncated, with very ſhort cilia.

It is of the number of the larger animalcula, the body is cryſtalline, and replete with black molecules, it's ſkin is perfectly ſmooth and colourleſs, it's hinder extremity is rounded, the anterior is truncated; there is a large opening viſible at this extremity, which ſerves as a mouth; this is thickly ciliated.

### 307. Vorticella Limacina. Fig. 60, Plate XXVI.

Vorticella cylindrica, truncata, ciliis bigeminis. Cylindrical truncated vorticella, with two pair of cilia.

### 308. Vorticella Fraxinina.

Vorticella gregaria, cylindracea, oblique truncata, ciliis bigeminis, apice margine fiſſa. Gregarious cylindrical vorticella, obliquely truncated, with two pair of cilia, and a fiſſure or notch at the upper edge.

The greater part of the body is cylindrical, the hinder-part is rather tapering, and filled with opake molecules; towards the upper end it is tranſparent; within the edge, at top, are two ſmall tubercles, from each ſide of which a pair of ſmall hairs proceed.

### 309. Vorticella Cratægaria.

See page 437 of this work.

### 310. Vorticella Hamata. Fig. 40, Plate XXVI.

Vorticella burſæformis, margine aperturæ aculeis rigidis. Purſe-formed vorticella, the edge of it's aperture or mouth ſet with rigid points.

It is not ciliated, nor have any hairs as yet been diſcovered about it; the body is granulated, the fore-part broad and truncated, the hinder-part obtuſe, and capable of being contracted or extended. a the rigid points.

### 311. Vorticella Crateriformis. Fig. 41, Plate XXVI.

Vorticella ſubquadrata, ciliorum faſciculis etiam poſtice. This vorticella is rather of a ſquare figure, and has faſcicles of cilia even at the hinder-part.

Lively, pellucid, round, longer than it is broad, approaching ſomewhat to a ſquare, with convex ſides; the head is ſituated at the large end, the ſkin is ſmooth, ſome traces of inteſtines are with difficulty diſcovered; at the larger end there is a conſiderable opening, ſurrounded by hair; the filaments compoſing this are in continual motion.

Two of theſe are ſometimes ſeen conjoined together, as at Fig. 41, and full of ſmall ſpherules; at this time they may without care be taken for freſh animalcula; they draw each other alternately different ways; in this ſtate the ſurface is ſmooth and the hairs inviſible. e moveable cilia.

## 312. Vorticella Canaliculata.

Vorticella dilatata, pellucida, latere inciſo. Dilated, pellucid, with an inciſion on the ſide.

To the naked eye it appears as ſo many white points adhering to the ſides of the glaſs; when magnified, the anterior part is narrower than the hind-one; in the ſide a kind of inciſion may be perceived, and the hind-part is a little notched towards the middle; it is furniſhed with a rotatory organ, by which it excites a continual whirling in the water.

## 313. Vorticella Verſatilis.

Vorticella elongata ſpiculiformis, mox urceolaris. Long ſpear-formed vorticella, but which often changes it's ſhape into a pitcher-like form.

A pellucid gelatinous animalculum, of a greeniſh colour, furniſhed with ſmall radii, particularly about the circumference, whence it may be conſidered as a minute water hedge-hog.

### 314. Vorticella Ampulla. Fig. 4 and 5, Plate XXVI.A.

Vorticella folliculo ampulaceo, pellucido, capite bilobo. This vorticella is contained in a pellucid bottle-ſhaped bag, the head of it is divided into two lobes.

Little more need be ſaid to enable the reader to know this animalculum, if he ſhould meet with it, than to obſerve that the bag is much in the ſhape of the common water-bottle; that the animalculum is ſometimes to be obſerved at the bottom of it, ſometimes nearly filling it.

### 315. Vorticella Folliculata.

Vorticella oblonga, folliculo cylindraceo hyalino: Oblong vorticella, in a bright cylindrical bag.

This animalculum is gelatinous and cylindrical; when at it's greateſt extenſion, the baſe appears attenuated, and the apex truncated.

### 316. Vorticella Larva.

Vorticella cylindrica, apertura lunata, ſpinis caudalibus binis. Cylindrical vorticella, the aperture ſomewhat in the ſhape of a creſcent, two ſmall thorny points projecting from the hinder-part.

The head, the trunk, and the tail may be eaſily diſtinguiſhed from each other. It is of a clay-colour, the aperture ciliated; a gloa globular projection may at times be ſeen to proceed from the aperture.

### 317. Vorticella Succolata. Fig. 42 and 43, Plate XXVI.

Vorticella inverſe conica, apertura lunata, trunco poſtice bidentato, cauda elongata biphylla. This vorticella is in figure an inverted cone, the aperture of a creſcent ſhape, the lower part of the trunk is notched, forming, as it were two teeth, the tail biphyllous.

Each of theſe parts is ſurrounded with a looſe bright ſkin, the head is divided from the trunk by a deep inciſion. a a a ſmall points projecting from the head, b the cilia, c and d the interior parts; l, Fig. 42, the little horn at the bottom of the trunk.

### 318. Vorticella Aurita.

Vorticella cylindrico-ventroſa, apertura mutica, ciliis utrinque rotantibus cauda, articulata biphylla. Cylindrical ventroſe vorticella, the aperture deſtitute of hairs, both ſides of it furniſhed with rotatory cilia, the tail biphyllous.

### 319. Vorticella Tremula.

Vorticella inverſe conica, apertura lobata ſpinuloſa, cauda brevi unicuſpi. This vorticella is ſomewhat of a conical ſhape, the mouth divided into parts which are ſet with ſmall ſpines or thorns, a point projects from the tail.

It is a pellucid, cryſtalline, ventricoſe animalculum; within it, on one ſide of the body, there is a large clay-coloured oval maſs, adjacent to which there is a pellucid oval ſubſtance; the tail is articulated and very ſhort.

### 320. Vorticella Senta.

Vorticella inverſe conica, apertura ſpinoſa integra, cauda brevi bicuſpi. Somewhat of the ſhape of a cone, the aperture ſet with ſpines, the tail ſhort, and divided into two points.

It has ſome reſemblance to the larger vorticella rotatoria, but is eaſily diſtinguiſhed from them by it's horned ſpiny aperture, and ſimple rotatory organ.

The body is muſcular, pellucid, folding variouſly, the fore-part truncated; round the margin of the aperture are rows of hairs, but ſtiffer hairs or ſpines are alſo continually vibrating, with which it draws in all animate and inanimate ſubſtances.

### 321. Vorticella Lacinulata. Fig. 45, Plate XXVI.

Vorticella inverſe conica, apertura lobata, ſetis binis caudalibus. In ſhape ſomewhat of an inverted cone, the aperture lobated, the tail ſmall, and furniſhed with two briſtles (d).

The body is muſcular, pellucid, cylindrical, the apex about a third part down, drawn into a little neck, the aperture or apex is ſpread on both ſides into a kind of flap or lappet, in the middle is a lita little lamina, or triangular point; another of theſe is diſcovered when the aperture faces the obſerver, which makes it appear like a ſmall flower. The hind-part, when in motion, is a little bent; it terminates in two minute briſtles, which are ſeen ſometimes united, at other times diverging. When the animalculum is ſwimming, it's rotatory organ (a) may be ſeen; molecular inteſtines are viſible; it moves with velocity in an oblique direction. Is found in pure water.

### 322. Vorticella Conſtricta.

Vorticella elliptico ventricoſa, apertura integra, cauda annulata biphylla. Elliptical ventricoſe vorticella, the aperture or mouth undivided, the tail annulated and forked.

In this kind, the head, the tail, and the trunk, are fully diſtinguiſhed. A ſubſtance in motion has been perceived, which has been ſuppoſed to be the heart; there are two kinds of them, one a pale yellow, the other of a white colour; they move by fixing their tail to the glaſs upon the ſtage, and then extending their body as much as poſſible; they fix the fore-part to the place where they intend to move, and then draw the hinder-part to it, and ſo on. They ſometimes turn round about upon one of the points of their tail, others ſpring forwards with a jerk. When at reſt, they open their mouths very wide, the lips are ciliated, two black globules are diſcovered in ſome of them.

### 323. Vorticella Togata.

Vorticella ſubquadrata, apertura integra, ſpinis caudalibus binis, plerumque unitis. Square vorticella, the aperture not divided, the tail conſiſting of two long ſpines, which are ſometimes ſo united as to appear as one.

The body is convex, of a dark colour, filled with molecules, the middle part pellucid, the hinder-part rather broader than the fore-part, the fore-part ciliated, the tail formed of two very thin pellucid ſpines, which are ſomewhat curved, and much longer than the body.

### 324. Vorticella Longiſeta.

Vorticella elongata, compreſſa, ſetis caudalibus binis longiſſimis. Long vorticella, flat, the tail formed of two very long briſtles.

The fore-part ſinuated, and ſet with minute cilia; the two briſtles which conſtitute the tail are long, but one is longer than the other.

### 325. Vorticella Rotatoria. Fig. 46, 47, 48, 49, Pl. XXVI. A.

Vorticella cylindrica, pedicello collari, cauda longa quadracuſpi. Cylindrical vorticella, with a little foot projecting from the neck, a long tail furniſhed with four points.

Brachionus corpore conico ſubæquali. Hill Hiſt. Anim.

Brachionus corpore conico toruloſo. Ditto.

Brachionus. Pallas Zooph. 50.

Joblot Microſ. part 2, p. 77, plate 10, fig. 18; and p. 96, plate 5, A B C D E K.

Adams's Micrographia Illuſtrata, p. 148, plate 40, fig. 255.

Leeuwenhoeck Contin. Arc. Nat. p. 386, f. 1, 2.

Baker's Microſ. Exp. p. 95, pl. 6, f. 6, 7, 8.

Baker's Empl. for the Micr. p. 348, 379, pl. 11, f. 1 to 13; and fig. 1, 2, 3, 6, 7, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, of plate XXVI. A, belonging to the work.

Spallanz. Opuſc. 2 p. 301, 345, pl. 4, f. 3 to 5.

Rozier Journal Phyſique, 1775, p. 220.

No perſon ſeems to have ſucceeded ſo well in the deſcription of the wheel animalculum as Mr. Baker, and all ſucceeding writers refer us to him for a full account of this little creature. What I ſhall ſay upon this animalculum will therefore be taken chiefly from him, though with ſuch additions and alterations as appear to me neceſſary to render his account complete.

It may be proper to obſerve, firſt, that Mr. Muller's wheel animal differs in ſome reſpects from that of Mr. Baker's; firſt, by the rotatory organs on the back, which ſtretch out like ears; ſecondly, the two little ſplendid ſubſtances within the body; and thirdly, the two black points near the top of the head, which are probably the creature's eyes.

This little animal is found in rain water that has ſtood for ſome days in leaden gutters, or in the hollows of lead on the tops of houſes, or in the ſlime and ſediment left in rain water; they are ſometimes to be found alſo in ditches and amongſt duck-weed.

It has been called the wheel animal becauſe it is furniſhed with a pair of inſtruments, which in figure and motion reſemble wheels. It appears only as a living creature when in water, and yet it may be kept for many months out of water, and in a ſtate as dry as duſt, without loſing the principle of life. When dry, it is of a globular form, about the ſize of a grain of ſand, and without any apparent ſigns of life. If it be put into the water, in the ſpace of half an hour a languid motion begins, the globule turns itſelf about, lengthens itſelf by ſlow degrees, becomes very lively, and in a little time protrudes it's wheels, and ſwims about in ſearch of food; or elſe, fixing itſelf by it's tail, brings the food to it by the motion induced on the water by it's rotatory organs.

If the water that is found ſtanding in gutters of lead, or the ſediment it has left behind, has any thing of a red colour, you may be almoſt ſure of finding theſe animalcula therein. In ſummer, when all the water is dried away, if the duſt appears red, or of a dark brown, and is put into water, you will ſeldom fail to diſcover, by means of the microſcope, a great number of minute reddiſh globules, which are the animalcula themſelves. It is moſt proper to obſerve them firſt with the third or fourth magnifiers, and then to uſe thoſe which are deeper.

This little creature has ſome likeneſs to a caterpillar; it's motion from place to place is performed like many of thoſe inſects, by firſt fixing the tail to ſome ſubſtance, then extending the whole body, and fixing the head, then drawing the tail to it; by theſe alternate actions it moves with ſome degree of ſwiftneſs.

It very often changes it's appearance, and aſſumes a different form; for the ſnout being drawn inwards, the fore-part becomes clubbed, and immediately dividing, exhibits to our view two circular inſtruments, ſet with minute hairs, that move very briſkly, ſometimes in a rotatory manner, ſometimes in a kind of trembling, or vibratory mode. An aperture, or mouth, is alſo perceived between the two ſemicircles; the animal may often be ſeen ſwimming about in purſuit of food while in this ſtate.

The moſt diſtinguiſhing parts of this animalculum are the head, the thorax, and the abdomen. The form and ſtructure of the head is wonderful, differing from any other creature hitherto deſcribed; the ſudden change of the head from one form to another is equally ſurprizing and ſingular; for from being of a very taper form, it becomes on a ſudden as broad as any part of the inſect, and protrudes an amazing piece of machinery, formed to procure it's food.

The circular bodies which project from them have much the reſemblance of wheels, and ſeem to turn round with conſiderable velocity, by which means a very rapid current of water is brought from a great diſtance to the mouth of the little creature; as theſe wheels are very tranſparent, except the edge, which is ſet with fibrillæ, (as cogs to a wheel) it is difficult to determine how they are turned about, or what is their real figure, whether they are flat, concave, or conical; be this as it may, they are protruded from a couple of tubular caſes, in which they can be again retracted, at the will and pleaſure of the animal. They do not always turn the ſame way, nor with the ſame velocity; they will ſometimes move in contrary directions, ſometimes both one way. The figure varies, from the degree of their protruſion, and from other circumſtances. They appear ſometimes like minute oblong ſquares, riſing from the periphery of a circle; at other times they terminate in ſharp points, ſometimes they are curved, bending the ſame way like ſo many hooks; now and then the ends appear clubbed, or in appearance like a number of little mallets.

When the fore-part of this creature is firſt ſeen to open or divide, the parts, which when fully protruded reſemble wheels, ſeem only like a couple of ſemicircles, the edges whereof are ſet with little ſpiculæ, having all a nimble and continual vibrating motion upwards and downwards, whereby the water becomes agitated, each wheel being in this caſe doubled, or like a round piece of paper folded in the middle.

When the wheels are in motion, the head appears very large in proportion to the ſize of the animal; and though it is then every-where tranſparent, yet a ring or circle, more particularly remarkable for it's brightneſs, may be perceived about the middle of the forehead; many veſſels may be ſeen to take their origin from this.

The thorax, or breaſt, is joined to the head by a ſhort annular circle, or neck; the thorax in ſize is nearly one-ſixth part of the whole animalculum. In it we diſtinctly perceive the heart of the little creature; the heart is placed almoſt in the middle, the diaſtole and ſyſtole cannot fail to catch the eye of every attentive obſerver. It is ſeen very plainly through the back, ſhutting and opening alternately with great regularity and exactneſs. It appears to be compoſed of two ſemilunar parts, wich in the time of contraction approach each other laterally, and form between them a figure ſomewhat like a horſe-ſhoe, whoſe upper ſide is flat, the under one convex. In the diaſtole theſe two parts ſeparate; the ſeparation begins exactly in the middle of the lower part next the tail. The alternate motions of the heart are performed with great ſtrength and vigour. In each of the ſemilunar parts there is a cavity, which cloſes when they come together, and opens when they ſeparate.

The motion of the heart is communicated to all the other parts of the thorax, and indeed through the whole animal we may perceive contractions and dilatations going on, that are apparently correſpondent thereto. It is neceſſary, however, to remark, that the motion of the heart is ſometimes ſuſpended, or at leaſt quite imperceptible for two or three minutes, after which it recommences, and goes on with the ſame vigour and regularity as before. From the under part of the thorax a ſmall tranſparent horn proceeds, which cannot be ſeen unleſs the inſect turns on it's back or ſide.

Below the thorax there is an annular circle that joins the thorax to the abdomen. The abdomen is much the largeſt part of this animal, it contains the ſtomach and viſcera. When this creature is full of food, the bowels are opake, and of a crimſon colour, extending from the thorax quite through the belly and a great part of the tail, and exhibits a fine view of the periſtaltic motion, or thoſe gradual contractions and dilatations of the inteſtines, which propel their contents downwards. There are many ramifications of veſſels, both longitudinal and tranſverſe, round the bowels. It can extend the abdomen in length very much, or contract and widen it conſiderably, ſo as to become a caſe for all the reſt of the body. The tail goes from a joint at the lower part of the belly to the poſterior extremity; it is of a tapering form, and conſiſts generally of three joints; when it is inclined to fix itſelf to any thing by the tail, it thruſts out four, ſometimes ſix, little hooks from the end thereof; theſe are placed in pairs, one pair at the very extremity itſelf, the other two a little way up the ſides; the three are ſeldom ſeen at the ſame time. The wheels ſeem to be the organ that the animal uſes to aſſiſt it in ſwimming.

All the actions of this creature ſeem to imply ſagacity and quickneſs of ſenſation; at the leaſt touch or motion in the water they inſtantly draw in their wheels. Mr. Baker conjectures that they have eyes lodged near the wheels, becauſe while they are in the globular or maggot ſtate, their motions are ſlow and blundering;

ing; but after the wheels are protruded, they are performed with great regularity, ſwiftneſs, and ſteadineſs.

Fig. 17, Plate XXVI. A, repreſents this little animal in what Mr. Baker calls the maggot ſtate; while in this form ſmall ſpiculæ are ſeen to dart out near the anterior part; the ſnout is ſometimes more and ſometimes leſs acute than in this delineation. (a) a ſmall horn near the thorax.

Fig. 15 repreſents it's manner of moving from place to place, while in the maggot ſtate.

Fig. 12 exhibits it, with the two ſemicircular parts, put out, and in the poſture it places itſelf in when it is preparing to ſwim about, or going to put it's wheels in motion.

Fig. 1 ſhews the head at it's full extent, with a couple of ſmall bodies on the top of it, armed with ſmall teeth like thoſe of the ballance-wheel of a watch.

At Fig. 18 the interior parts are more particularly exhibited. (a) the circle from which many veſſels originate; (b) the thorax, or breaſt, joined to the head by the neck (c.) The part which is ſuppoſed to be the heart is plainly ſeen at (d.) The abdomen (f) is ſeparated from the breaſt by a ring (e). (g) the tail.

Fig. 19 is the wheel animal, not full extended, but yet working it's wheels about.

Fig. 20 ſhews it with it's ſide towards the eye; one of the wheels in this poſition appears to lie conſiderably below the other.

Fig. 6 and 16 repreſent two of theſe creatures in the poſtures they are often ſeen in when the wheels are not out, but the fiibrillæ are vibrating quickly.

Fig. 2, it is ſeen with the body nearly drawn into the abdomen; at Fig. 21 it is ſtill further drawn in; at Fig. 22 as it appears juſt as the tail is drawn in; at Fig. 23 in a globular form, but ſtill adhering by the tail.

Sometimes, when in the maggot form, it rolls it's head and tail together, without drawing them into it's body; it is repreſented in this ſtate at Fig. 14.

Mr. Baker has alſo deſcribed three other ſpecies, one of which, that differs only from the preceding in having a very long tail, is repreſented at Fig. 7, Plate XXVI. A.

Fig. 11 is another kind, with cruſtaceous ſpiculæ at the forepart; within this, at c, an opake oval body may be ſeen, which has been taken for an egg.

Fig. 3 is another kind; it has two projecting points from the tail, and the head furniſhed with a number of fibrillæ.

Fig. 13 repreſents another ſpecies, deſcribed by Spallanzani.

Fig. 46, 47, 48, 49, Plate XXVI. repreſent the wheel animals, ſeen and delineated by Mr. Müller. a the head, b the eyes, c a ſmall horn, d the rotatory organ, e the tail, f the points of the tail.

### 326. Vorticella Furcata.

Vorticella cylindrica, apertura integra, cauda longiuſcula bifida. Cylindrical vorticella, the aperture undivided, the tail rather long, and divided into two parts.

A cylindric body, with a rotatory organ, or row of hairs, at the apex; the tail divided into two parts, a little turning inwards. When at reſt, it joins the ſegments of the tail; but when in motion, it ſeparates them. Generally found in common water.

### 327. Vorticella Catullus. Fig. 50, Plate XXVI.

Vorticella cylindracea, apertura mutica, cauda per brevi, reflexa, bicuſpi. Cylindrical vorticella, the aperture plain, the tail ſhort, bent back, and divided into two points.

It is a little thick animalculum, muſcular, folding itſelf up, of an equal breadth throughout, the body disfigured by longitudinal folds, winding variouſly; the anterior part, or head, connected to the body by a little neck, it occaſionally manifeſts a very minute rotatory organ. The tail (e) is ſhort, terminating in two very ſmall briſtles (d), which it moves and hides at pleaſure; the inteſtines ill-defined. It's motion is rotatory, but in various directions. Is found commonly in marſhy waters.

### 328. Vorticella Canicula.

Vorticella cylindracea, apertura mutica, cauda brevi, articulata, bicuſpi. Cylindrical vorticella, the aperture plain, the tail ſhort, articulated, and dividing into two pointed parts.

### 329. Vorticella Felis.

Vorticella caudata, cylindracea, mutica, cauda ſpinis duabus longis terminata. With a tail, cylindrical, beardleſs, the tail terminating in two long ſpines.

The body is large, the apex of an equal thickneſs, obtuſe, with rotatory filaments; the tail acute, with two pellucid ſpines, about one-third of the body in length, ſeparating from and then approaching each other alternately.

### 330. Vorticella Stentorea.

See page 429 of this work.

### 331. Vorticella Socialis.

See page 432 of this work.

### 332. Vorticella Floſculoſa. Fig. 51 and 52, Plate XXVI.

Vorticella caudata aggregata, oblongo-ovata, diſco dilatato pellucido. With a tail aggregated, of an oblong oval ſhape, with a dilated pellucid diſc.

To the naked eye it appears as a yellow globule, adhering to the ceratophyllon (a) like a little flower (b), or like a heap of yellow eggs. By the microſcope they are diſcovered to be a congeries of vorticellas, conſtituting a ſphere from a mouldy center. They either ſingly, or many of them together, extend and contract their little bodies, and by means of the diſc excite a vortex in the water.

Sometimes they quit the ſociety, and act ſingly; they may then be obſerved more eaſily, and will be found to conſiſt of three parts, a head, abdomen, and tail. The head is often ſo drawn back into the abdomen (d), that no veſtige of it remains; but it exhibits a broad diſc ſtanding out, of a kidney-ſhape. The abdomen (d) is an oblong, oval, pellucid, replete with obſcure inteſtines, amongſt which are one or two remarkable black oval ſpots (e); the tail is ſharp, and as long again as the abdomen, rough and annulated, or altogether ſmooth.

### 333. Vorticella Citrina. Fig. 53, Plate XXVI.

Vorticella ſimplex, multiformis, orificio contractili, pedunculo æquali. Simple, many-ſhaped, with an orifice that it can contract, and equal-ſized foot-ſtalk.

The head is full of molecules, round, and every-where of an equal ſize; very pellucid, both ſides of the orifice are ciliated, and each has a rotatory motion, appearing ſometimes without the edge of the mouth, as at a a; ſometimes within it. No diſtinct inteſtines, or internal motion, perceivable. It's motion is different from moſt of this genus, but not eaſily deſcribed. c c ſmall feet. It is found in ſtagnant water.

### 334. Vorticella Piriformis.

Vorticella ſimplex, obovata, pedicello minimo retractili. Simple, ſomewhat oval, with a very ſmall retractile foot, or one which it can draw within itſelf.

### 335. Vorticella Tuberoſa.

Vorticella ſimplex, turbinata, apice bituberculata.

Simple vorticella, the upper part broad, the under part ſmall, with two projecting parts at the anterior end, which are furniſhed with a number of vibrating fibrillæ, that produce a current of water by their quick motion, and thus collect food for our vorticella. Mr. Baker has delineated it in Fig. 10, 11, 12, Plate XIII. of his Employment for the Microſcope.

### 336. Vorticella Ringens.

Vorticella ſimplex, obovata, pedunculo minimo, orificio contractili. Simple, ſomewhat of an oval ſhape, a ſmall pedicle, an orifice that it contracts or dilates.

The ſmall head, or rather body, of this little creature is pear-ſhaped, pellucid, the middle of the aperture convex, both ſides ciliated, the pedicle four times ſhorter than the body; it can contract the orifice to an obtuſe point.

### 337. Vorticella Inclinans.

Vorticella ſimplex, deflexa, pedunculo brevi, capitulo retractili. Simple, bent, with a ſhort pedicle, and ſmall retractile head.

A pellucid pendulous little head, the anterior part truncated, and is occaſionally, by contraction, made twice as ſhort as the pedicle; it's ſhape is like that of a tobacco-pipe.

### 338. Vorticella Vaginata.

Vorticella ſimplex, erecta, ovato-truncata, pedunculo vaginato. Simple vorticella, erect, of the ſhape of a truncated egg, the pedicle contained in a ſheath.

For the 339th, 340th, and 341ſt, the author refers to the Zool. Dan. he terms them vorticella cyathina, vorticella putrina, vorticella patellina.

### 342. Vorticella Globularia.

Vorticella ſimplex, ſphærica, pedunculo retortili. Simple, ſpherical, with a twiſted pedicle.

The little head is ſpherical, the aperture of the mouth ciliated, the pedicle four times longer than the body, which it contracts in a ſpiral form. It is frequent among the cyclope quadricorni.

### 343. Vorticella Lunaris. Fig. 54, Plate XXVI.

Vorticella ſimplex, hemiſphærica, pedunculo retortili. Simple, hemiſpherical, with a twiſted pedicle.

The ſmall head of this animalculum is crater-form (goblet-ſhaped), the margin of the orifice protuberant, ciliated on both ſides, the hairs undulating, the pedicle eight or ten times the length of the body. As often as the mouth is opened, the pedicle extends itſelf; when it is ſhut, this is twiſted up ſpirally, and theſe motions are often reiterated in a ſhort ſpace. a the head when expanded, b when ſhut, c the undulated edge, d the cilia erect, e when horizontal, f the pedicle when ſtrait, g when bent.

### 344. Vorticella Convallaria.

See page 445 of theſe eſſays.

### 345. Vorticella Nutans.

Vorticella ſimplex, turbinata, pedunculo retortili. Simple, with a twiſted turbinated pedicle.

The pedicle is ſimple, and twiſts itſelf ſpirally, is exceeding ſlender, and has a kind of cap on the head; the margin white and round, and as it were encompaſſed with a lucid ring; the head diminiſhes towards the baſe. It is tranſparent.

### 346. Vorticella Nebulifera. Fig. 66, Plate XXVI.

Vorticella ſimplex, ovata, pedunculo reflexili. Simple, egg-ſhaped, the pedicle bent back.

The body is narrow at the baſe, open and truncated at top, the margin as it were ſurrounded with a ring; but when the aperture is ſhut, the animalculum is egg-ſhaped, the inteſtines may be ſeen diſtinctly, the pedicle is ſimple, ſetaceous, conſiderably longer than the body, and generally much bent back. a the head open, b almoſt ſhut, c quite ſhut, d the ſtalk when ſtrait, at e it is bent.

### 347. Vorticella Annularis.

Vorticella ſimplex, truncata, pedunculo apice retortili. Simple, truncated, with a pedicle twiſted at the end.

This is viſible to the naked eye; the head an inverted cone, convex when the mouth is ſhut, truncated when it is open, with a protuberant edge, the pedicle is ſimple, very long, thick, and whiter at the top than elſewhere, formed into a little head, the apex is twiſted ſpirally. This animalculum, when contracted, appears to be annulated.

### 348. Vorticella Acinoſa.

See page 440 of this work.

### 349. Vorticella Faſciculata.

Vorticella ſimplex, viridis, campanulata, margine reflexo, pedunculo retortili. Simple, green, bell-ſhaped, the margin or edge turned back, the pedicle twiſted.

A congealed green maſs, which is often ſwimming about in ditches, is compoſed of myriads of theſe animalcula, which are not viſible to the eye; when magnified, they appear as a bundle of green flowers. The head is bell-ſhaped, green, opake, narrow at bottom, pellucid. It has a rotatory organ, which may ſometimes be ſeen projecting beyond the aperture; the pedicle is twiſted and very ſlender; a little head at the apex.

### 350. Vorticella Hians.

Vorticella ſimplex, citriformis, pedunculo retortili. This is among the moſt minute. The head reſembles a citron, the apex truncated, the baſe narrow; a gaping cleſt is diſcovered deſcending from the apex to one-third of the body.

### 351. Vorticella Bellis.

Vorticella ſimplex, hemiſpherica, margine contractili. Simple, hemiſpherical, with a margin that it can contract at pleaſure.

The head (capitulum) ſcarcely pellucid, the inſide quite filled, yellow, reſembling much the flower of the daiſy; it is ciliated round the margin, and are in great abundance, moving in a rotatory manner.

The foot, or pedicle, is long, ſlender, and pellucid; it is divided into two parts, with ſmall knobs on the top of each; the baſe adheres to a bulb, the under part is covered with ſmall ſcales.

### 352. Vorticella Gemella.

Vorticella ſimplex, ſphærica, capitulo gemino. Simple, ſpherical, with a double head.

The pedicle is long, and conſtantly furniſhed with two little heads at it's apex; theſe are bright and clear.

### 353. Vorticella Pyraria.

See page 437 of this work.

### 354. Vorticella Anaſtatica.

See page 434 of theſe eſſays.

### 355. Vorticella Digitalis.

See page 444 of this work.

### 356. Vorticella Polypina. Fig. 61, Plate XXVI.

Vorticella compoſita, ovato-truncata, pedunculo reflexili ramoſiſſimo. Compound vorticella, oval, truncated, with a bending branching ſtalk.

When viewed with a ſmall magnifier, they appear like ſo many little trees; the upper part, or heads, are egg-ſhaped, the top truncated, the lower part filled with inteſtines; the branches are thick ſet with little knobs. a the trunk, b the branches, c the head when extended, f the ſmall knobs thereon.

### 357. Vorticella Racemoſa.

Vorticella compoſita, pedunculo rigido, pedicellis ramoſiſſimis longis. Compound, pedicle rigid, with ſmall branched long feet.

To the naked eye it appears like the vorticella ſocialis, but is diſtinguiſhed from it by always adhering to the ſides of the veſſel in which it is placed. On examining it with a magnifier, a long very fine pedicle is perceived ſticking to the ſides of the veſſels, from which proceed an innumerable quantity of cryſtalline pellucid pearls, which, together with the ſtalk, are variouſly agitated in the water. They ſometimes move ſeparately, ſometimes together, are ſometimes drawn down to the root, and in a moment again expanded.

## XVII. BRACHIONUS.

Vermis contractilis, teſta tectus, ciliis rotatoriis. A worm capable of contracting, covered with a ſhell, and furniſhed with rotatory cilia.

### 358. Brachionus Striatus. Fig. 64 and 65, Plate XXVI.

Brachionus univalvis, teſta ovata ſtriata, apice ſexdentata, baſi integra, cauda nulla. Univalved brachionus, the ſhell oval and ſtriated, ſix notches or teeth round the upper edge, the baſe whole or even, without a tail.

The ſhell is oblong, pellucid, and capable of alterations in it's figure. The apex (a) truncated, with ſix ſmall teeth on the edge of it, twelve longitudinal ſtreaks down the back, the baſe obtuſe and ſmooth. The teeth are occaſionally either protruded or retracted; on the other ſide of the ſhell, towards the tail, there are two little ſpines or horns (c).

The animalculum is pellucid, cryſtalline, and muſcular, often of a yellow colour; from the apex it now and then puts forth three little bundles of playing hairs, the two lateral ones ſhorter than the middle one; a forked deglutatory muſcle (e) may be perceived, and on the under ſide, when the apex is drawn in, we diſcover two rigid points. It is an inhabitant of the ſea.

### 359. Brachionus Squamula.

Brachionus univalvis, teſta orbicularis, apice truncata quadridentata, baſi integra, cauda nulla. Univalved brachionus, with an orbicular ſhell, the apex truncated, and having four teeth, the baſe ſmooth, no tail.

### 360. Brachionus Pala.

Brachionus univalvis, teſta oblonga excavata, apice quadridendata, baſi integra, cauda nulla. Univalved brachionus, with an oblong excavated ſhell, four long teeth at the apex, the baſe ſmooth, no tail. It is of a yellow colour.

### 361. Brachionus Bipalium.

Brachionus univalvis, teſta oblonga inflexa, apice decemdentata, baſi integra, cauda ſpuria. Univalved brachionus, the ſhell oblong and inflected, ten teeth at the apex, the baſe ſmooth, a ſpurious tail.

### 362. Brachionus Patina.

Brachionus univalvis, teſta orbiculari integra, cauda mutica. Univalved brachionus, with an orbicular ſhell, the edges regular, and having a long beardleſs tail.

This animalculum is large, the ſhell cryſtalline, nearly circular, without any teeth or inciſion, though towards the apex it rather falls in, ſo as to form a ſmooth notch. This little creature is remarkably bright or ſplendid; it is affixed to the middle of the ſhell; it projects from the apex a double glittering organ, the edges of which are ciliated; both theſe organs are of a conical figure, and ſtand as it were upon a pellucid ſubſtance, which is divided into two lobes; between theſe lobes and the rotatory inſtrument there is a ſilver-coloured crenulated membrane; two ſmall claws may be diſcovered near the mouth and other organized parts.

### 363. Brachionus Clypeatus.

Brachionus univalvis, teſta oblonga, apice emarginata, baſi integra, cauda mutica. Univalved brachionus, the ſhell oblong, the apex notched, the baſe ſmooth, the tail naked.

### 364. Brachionus Lamellaris.

Brachionus univalvis, teſta producta, apice integra, baſi tricorni, cauda bipili. Univalved brachionus, the ſhell extending conſiderably beyond the body, the baſe divided into three ſmall horns, at the end of the tail there are two hairs.

### 365. Brachionus Patella.

Brachionus univalvis, teſta ovata, apice bidentata, baſi emarginata, cauda biſeta. Brachionus with a univalve oval ſhell, two teeth at the apex, the baſe notched, two briſtles at the tail.

The ſhell plain, oval, orbicular, cryſtalline, the anterior part terminating in two acute points on both ſides, though the head of the animal for the moſt part fills up the intervening ſpace.

The head, the tail, and the trunk are very diſtinct; the bottom of the trunk is terminated in a ſemicircle, the fore-part marked with two tranſverſal lines; it occupies the diſc of the ſhell. The inteſtines are indiſtinct, the tail is affixed to the trunk; it is ſhort, annulated, flexible, the middle projecting beyond the ſhell, the apex diverging into two very fine briſtles (g); it faſtens itſelf by theſe, and whirls about with the body erect; the rotatory cilia (c) are with great difficulty perceived. Found in marſhy water all the winter.

### 366. Brachionus Bractea.

Brachionus univalvis, teſta ſuborbiculari, apice lunata, baſi integra, cauda ſpina duplici. Univalved brachionus, the ſhell rather orbicular, the apex lunated, the baſe ſmooth, the tail furniſhed with two ſpines.

### 367. Brachionus Plicatilis.

Brachionus univalvis, teſta oblonga, apice crenulata, baſi emarginata. Univalved brachionus, with an oblong ſhell, the apex hairy, the baſe notched.

### 368. Brachionus Ovalis.

Brachionus bivalvis, teſta depreſſa, apice emarginata, baſi inciſa, cauda cirro duplici. Bivalved brachionus, with a flattened ſhell, the apex notched, a hollow part at the baſe, the tail formed of two tufts of hair.

### 369. Brachionus Tripos. Fig. 59, Plate XXVI.

Brachionus bivalvis, teſta apice mutica, baſi tricorni, cauda duplici. Bivalved, the apex of the ſhell beardleſs, three horns at the baſe, double tail.

The body is pellucid, nearly triangular, bivalved, open on the back of the animalculum; from the orifice two little laminæ proceed, that are larger than the rotatory cilia; at the bottom are three or four ſtiff points e f a, and a moveable tail (g) between them, divided into two filaments, which the little creature opens and ſhuts at pleaſure; by theſe it fixes itſelf to objects. a the lateral cilia, b two ſmall laminæ, c a deglutatory muſcle, e an opake maſs.

### 370. Brachionus Dentatus.

Brachionus bivalvis, teſta arcuata, apice et baſi utrinque dentata, cauda ſpina duplici. Bivalved brachionus, with an arched ſhell, the apex and the baſe are both toothed, the tail formed of two ſpines.

### 371. Brachionus Mucronatus.

Brachionus bivalvis, ſubquadrata, apice et baſi utrinque mucronata, cauda ſpina duplici. Bivalved, ſomewhat of a ſquare form, the baſe and apex pointed, the tail conſiſting of two ſpines.

### 372. Brachionus Uncinatus. Fig. 55, Plate XXVI.

Brachionus bivalvis, teſta ovali, apice integra, baſi mucronata, cauda rugoſa biſeta. Bivalved brachionus, with an oval ſhell, the apex even, the baſe pointed, two thick briſtles for the tail.

This is one of the ſmalleſt bivalved animalcula, the apex and anterior part round, the hinder-part ſtrait, terminating in a point, muſcular, furniſhed with a hook on the fore-part, a ſmall rotatory organ, a tail compoſed of joints, long, and cloven at the end into two briſtles. It can open it's ſhell both at the fore and hind-part. a the ſhell when cloſe, c the poſterior point, d the animalculum, h the tail, i the briſtles.

### 373. Brachionus Cirratus.

Brachionus capſularis, teſta apice producta, baſi curti, bicorni, cauda biſeta. Larger than the preceding, ventricoſe, ſomewhat pellucid, the head conical, on both ſides of which is a bundle of hairs; it has alſo a rotatory organ.

### 374. Brachionus Paſſus.

Brachionus capſularis, teſta cylindracea, frontis cirris binis pendulis, ſetaque caudali unica. Capſular brachionus, in a cylindric ſhell, two long pendulous locks of hair proceed from the front, the tail conſiſts of a ſingle briſtle.

### 375. Brachionus Quadratus.

Brachionus capſularis, teſta quadrangula, apice bidentata, baſi bicorni, cauda nulla. Capſular brachionus, in a quadrangular ſhell, with two ſmall teeth at the apex, two horns proceed from the baſe, it has no tail.

### 376. Brachionus Impreſſus.

Brachionus capſularis, teſta quadrangula, apice integra, baſi obtuſi emarginata, cauda flexuoſa. Capſular brachionus, the ſhell quadrangular, the apex ſmooth or undivided, the baſe obtuſe, the margin notched, the tail flexuous or bending.

### 377. Brachionus Urceolaris.

Fig. 56 and 57, Plate XXVI. and Fig. 36, 37, 38, Plate XXII.

For a full deſcription of this ſee page 448.

### 378. Brachionus Bakeri. Fig. 58, Plate XXVI.

Brachionus capſularis, teſta ventricoſa, apice quadridentata, baſi bicorni, cauda longa, bicuſpi. Capſular brachionus, the ſhell ventricoſe, four teeth at the apex, two horns at the baſe, the tail long, and terminating in two ſhort points.

This differs conſiderably from the foregoing in the ſhape of the ſhell, from each ſide of which there is a curved projection inclining towards the tail, nearly of the ſame length with it, and terminating in a point. The upper part alſo of the ſhell is of a different form, having in general four longer ſpiculæ, and two ſhorter ones. From the head two arms, or branches, are frequently extended; the circular end of each is furniſhed with a border of little hairs, which one while move in a vibratory manner, at another time they have a rotatory motion. The eggs are either affixed to the tail, or the curved part of the ſhell; they have from one to five hanging from them. Mr. Muller has further diſcovered two ſmall feelers, and a kind of tongue to this little creature. a the rotatory organ, b the tongue, c the feelers, d a ciliated part on the ſide of the ſhell.

### 379. Brachionus Patulus.

Brachionus capſularis, teſta ventroſa, apice octodentata, baſi lunata quadricorni, cauda brevi bicuſpi. Capſular brachionus, the ſhell ventroſe, eight teeth at the apex, the baſe lunated or hollowed into the form of a creſcent, and furniſhed with four horns, the tail ſhort, with two ſmall points at the end.

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## CHAP. IX.

### ON THE ORGANIZATION OR CONSTRUCTION OF TIMBER, AS VIEWED BY THE MICROSCOPE.

THE ſubject of the following chapter opens an extenſive field of obſervation to the naturaliſt, in which the labour of a life may be well employed: it is a branch where the obſerver will find the microſcope of continual uſe, and without which he will ſcarce be able to form any juſt idea of the organization of trees and plants, of the variations in the diſpoſition, the number, nature, and offices of the ſeveral parts thereof.

Malphigi, Grew, Duhamel, Hill, Bonnet, and De Sauſſure, are almoſt the only writers who have treated on this ſubject; and if we conſider the imperfection of the inſtruments uſed by ſome in thoſe anatomical reſearches, and the little attention paid by the reſt to the advantages their favorite purſuits might have derived from the uſe of the microſcope and the diſſecting knife, we have rather more to wonder at what has been done, than at what remains to be performed. One reaſon that our knowledge of the ſubject of this chapter is ſo circumſcribed, is the general inattention

tion to the ſtructure of plants; to this, among other cauſes, we may alſo aſcribe the inſtability and fluctuation of the different theories on the principles of vegetation. We are, however, ſo little acquainted with the ſteps which Providence takes to lead intellectual, but free agents, to the knowledge of truth, and the various difficulties, errors, and prejudices that muſt be removed before it can ſhine in it's native colours, that it is our duty to encourage every humble effort towards the advancement of ſcience, that thus we may co-operate with our Creator and Redeemer in promoting that vaſt plan to which all things are now converging, the bringing all his creatures to a ſtate of truth, goodneſs, and conſequent happineſs, an end worthy of the beſt and wiſeſt of beings.*

As Dr. Hill is the firſt writer who has treated this part of natural hiſtory in an orderly and ſcientific manner, I ſhall uſe the names he has adopted for characterizing the different parts of trees, &c. which are, 1. the rind; 2. the bark; 3. the blea; 4. the wood; 5. the corona or circle of propagation; 6. the pith. Theſe are placed immediately within or under one another; they are the eſſential parts upon which the ſtrength of the tree depends: in, among, and between theſe, the various veſſels are placed, which nouriſh the whole, and maintain and carry on the vegetation of the tree, and from which it obtains it's peculiar qualities and virtues. Theſe veſſels are of five kinds.

JUICE

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* See the Biſhop of Exeter's Sermon before the Society for the Propagation of the Goſpel.

## JUICE VESSELS.

1. The exterior veſſels, placed between the rind and the bark.
2. The interior, in the ſubſtance of the bark.
3. The intimate, in the ſubſtance of the blea.
4. The ſap veſſels, in the ſubſtance of the wood.
5. The coronal, in the corona.

More accurate inſtruments, or a more minute inveſtigation of the parts, may probably diſcover new veſſels, in a ſyſtem which appears to be entirely vaſcular, and bring us more thoroughly acquainted with the nature of vegetation.

## OF THE RIND.

The exterior covering of all trees is a thin, dry, parched ſubſtance, which has been compared by many writers to the ſkin of animals, and called by names analogous thereto; thus it is called the epidermis by Duhamel, the ſkin by Grew, the rind by Hill.

When a tree is full of ſap, this membrane may be eaſily detached from the part it covers; it may be ſeparated from green branches which are not in ſap, by boiling them in water; large pieces of it may alſo be obtained from rotten branches; the rind of the leaves of many trees is detached with ſingular dexterity from the other parts, by ſome of the mining caterpillars; artificial methods for effecting this purpoſe have been deſcribed in page 159 of this work. Though the rind may at firſt ſight be thought to be of little uſe, it will be found to be a principal organ in the proceſs of vegetation; the part which covers the root has the moſt important offices aſſigned to it.

Many are of opinion that the rind is formed of dried veſicula; and Malphigi ſays, that we may ſee in the vaſcular texture of the bark of the cherry and plumb trees an arrangement of the parts proper to form the rind, and this arrangement is occaſioned by the endeavour of the vaſcular part to extend itſelf to the circumference, and the reſiſtance it meets with from the rind; and that hence the veſſels are flattened, and aſſume a membranaceous form.

The rind is a general covering to the young trunks of trees, to the branches, the roots, the leaves, the fruit, the flowers, &c. Upon the trunks of large trees ſome pieces only of the rind are to be found, having probably been broke by the increaſed ſize of the tree. The rind of ſome ſpecies of trees will bear being ſtretched much further than thoſe of others, and remain for a conſiderable time uniformly ſpread over the bark. Duhamel aſſerts, that the rind of vigorous healthy trees remains longer whole than on thoſe that are more languid, notwithſtanding that the growth of the laſt is ſlower, and therefore makes leſs efforts againſt the rind. This circumſtance is much in favour of the diſtinct organization of the rind, and againſt the opinion of thoſe who only ſuppoſe it to conſiſt of dried bladders.

Thin as the rind is, it is formed of many coats, adhering cloſely to each other, which in ſome ſpecies may be ſeparated with eaſe, in others with difficulty. Duhamel ſays, that he has divided the rind of the birch into ſix diſtinct coats, and that he had no doubt but what the diviſion might have been carried much further. Dr. Hill ſays, that unleſs ſome of theſe coats are obtained in a ſtate of ſeparation from the reſt, the true conſtruction of the rind cannot be diſcovered, for the connection and form of the parts is loſt by the confuſion in which they appear while they lie one upon another.

The following experiments may throw a little light upon this obſcure ſubject.* All the rind was taken from the trunk of a cherry tree, and the tree thus ſkinned, expoſed to the air, a part of the bark which was next to the rind dried up and exfoliated; the part next to this did the ſame; after two or three exfoliations, a farinaceous ſubſtance covered the ſuperficies of the trunk, ſoon after which a new rind appeared. Some pieces of rind were taken from a few young branches, and the wounds were covered with a cloth that had been ſoaked in wax and turpentine; on theſe the rind appeared in a very little time, without any apparent exfoliation. From ſome other branches, not only the rind, but a part of the bark, was alſo taken away, and the wounds covered as before; a ſlight exfoliation was obſerved here, which was ſoon followed with a new rind. The bark was taken entirely off from a vigorous cherry-tree, while it was in full ſap, ſo that the wood appeared the whole extent of the trunk. This was protected from the rays of the ſun, and from the air. A new bark and rind formed themſelves upon the trunk, but they did not originate from the bark that was left on the branches and the root, but extended from different ſpots, which were firſt formed at conſiderable diſtances from each other. After a lapſe of fifteen years, this new rind did not appear like the natural rind of the cherry-tree. From theſe experiments we learn, that the rind regenerates more readily in ſome caſes than in others, and that it preſerves and prevents in a degree the bark from becoming dry too ſoon, and in conſequence thereof exfoliating.

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* Duhamel Phyſique des Arbres, tom. 1, p. 12.

Aided by the microſcope, a number of luminous points may be diſcovered in the rind;* theſe are ſo many minute holes for other purpoſes of tranſpiration. In the cane theſe holes are viſible to the naked eye. A few oval holes may alſo be perceived in it; theſe are, however, no more than a ſeparation of the parts, occaſioned by the extenſion of the vaſa interiora.

Dr. Grew ſuppoſed the rind to be formed of ſmall veſicles, or bladders, cluſtered together, and intermixed with lignous fibres or veſſels, which run through the length of the rind; theſe are conjoined by other tranſverſe ones, but that as the rind dries, the bladders or blebs ſhrink up and diſappear. This account does not differ much from that of Dr. Hill, who ſays, that the rind is formed of a ſeries of longitudinal veſſels, and a filmy ſubſtance between them, which, when viewed in a tranſverſe ſection, form ſmall circles, the ſides of which are ſupported and made up of theſe longitudinal fibres; that the tranſverſe veſſels are only a deception, occaſioned by the ſpaces between part and part of the film. The mode of obtaining an accurate view of the organization of this part, by conveying coloured liquors into the ſeveral veſſels thereof, has been already deſcribed in page 162 of theſe

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* Duhamel Phyſique des Arbres, vol. 1, p. 9.

eſſays; by this means, together with the microſcope, we find that the veſſels are every-where pierced with ſmall dots, or openings; of the uſe of theſe the following conjectures have been formed.*

The root, which is equal in ſurface to a third part of the tree above ground, is covered with a pierced rind. The cold of winter contracts the whole of this, the parts are drawn cloſer together, and the mouths of theſe innumerable veſſels are ſhut, or nearly ſo, by this contraction; a very little of the half congealed moiſture of the ground gets into them, but this ſuffices for the ſervice of the tree, when there is little heat to cauſe any perſpiration, and at a time when in the deciduous trees, the very organs of the greateſt perſpiration, the leaves, do not exiſt.

The warmth of ſpring arrives, the fluids of the earth grow thinner, every part of the root expands; this opens the mouths of the veſſels, and the torrent of nutrition ruſhes in. By this means, every coat of the rind, and the interſtitial ſpaces thereof, are rendered ſupple, and may be eaſily ſeparated from the under coverings.

In roots the colour of the rind varies very much, being white in ſome, brown in others, &c. Every root, according to Grew, after it has arrived at a certain age, has a double ſkin, the one coeval with the other parts, and exiſts in the ſeed: a ring is afterwards ſent off from the bark, which forms the ſecond ſkin; thus in the root of dandelion, towards the end of May, the original or outer ſkin appears ſhrivelled, and is eaſily ſeparated from the new one, which is freſher, and adheres more firmly to the bark. Perennial plants are ſupplied in this manner with a new ſkin every year; the outer one always falls off in the autumn and winter, and a new one is formed from the bark in the ſucceeding ſpring.

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* Hill's Conſtruction of Timber, &c. p. 37.

### OF THE VESSELS WHICH ARE CONTAINED BETWEEN THE RIND AND THE BARK.

Theſe are called by Duhamel the cellular coat, (enveloppe cellulaire) by Hill the exterior veſſels, and the vaſa propria exteriora.

It has been already obſerved, that in trees the juice veſſels, or vaſa propria, do not form thoſe conſtituent parts of the wood of which the timber conſiſts, but that it is from the nature of theſe recipient veſſels that it derives it's virtues, qualities, and ſpecific properties.* A tree may grow, live, and give ſhade without them; but on thoſe it's peculiar character and decided virtues depend; theſe are greateſt where the vaſa propria are largeſt or moſt numerous, and where we do not find theſe, we ſcarce find any thing that will affect the taſte or the ſmell. There are different ranges of theſe veſſels between the ſeveral parts, each of which has it's allotted place, it's peculiar form, it's different ſtructure, and it's ſeparate uſe. Many trees have them in all their parts, others only in ſome of them, while others do not exhibit any.

On taking off the rind, we find a ſubſtance of a deep green colour, ſucculent and herbaceous, formed of a prodigious number of

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* Hill's Conſtruction of Timber, p. 73.

prived of the bark; becauſe they have rays of the ſame ſubſtance within, which anſwer the purpoſe, and this in a degree anſwering to the nature of their life.

The bark appears to be formed, firſt, of longitudinal fibres, which Duhamel conſiders as ſo many lymphatic veſſels; ſecondly, by a kind of a filmy cellular tiſſue, which have been conſidered as a kind of bladders by ſome, or as parenchymous by others; thirdly, of the vaſa propria interiora, or interior juice veſſels.

The longitudinal fibres are diſpoſed in ſtrata, which lie one over the other. In that ſtratum which is next the rind, or rather the cellular coat, we perceive a net of longitudinal fibres, the meſhes of which are large and eaſily diſtinguiſhed, particularly when the cellular tiſſue that fills up the interſtices is removed. To do this, the branches ſhould be macerated for a conſiderable time; ſome require to be kept in this ſtate for years. It will then be eaſy to ſeparate firſt the rind, then the cellular coating, and afterwards this pulpy matter. It may ſometimes be eaſily removed after the branches have been boiled.

The moſt exterior ſtratum, when examined by the naked eye, ſeems to be formed of ſimple fibres, which graft, ſolder, or anaſtomoſe one with the other; but when examined by a microſcope, each of theſe fibres will be found to be a bundle of filaments, which may be eaſily ſeparated from each other.

Grew ſays, that each filament, like the nerves in animals, conſiſts of twenty or thirty ſmall contiguous tubes, which run uniformly from the extremity of the root, without ſending off any branches, or ſuffering any change in their ſize and ſhape. Hence the bark may be tore or divided lengthways, with greater eaſe than in an horizontal direction; when macerated, they are capable of a very great degree of ſubdiviſion.

The filaments of a cortical veſſel are to be looked on (agreeable to what we have already obſerved) as ſo many little bundles placed near together, and at firſt growing parallel to each other; but ſoon quitting this direction, the filaments of one faſcicle parting from that to which they originally belonged, and inclining more or leſs obliquely towards another, ſometimes uniting with it, at others bending backwards, and uniting again with that from which it proceeded, or with ſome one that it meets with. In this manner new faſcicles are often formed, while other parcels are increaſed or diminiſhed by the additions of new filaments; by this means, a kind of irregular net is formed, and the fibres proceed in a ſerpentine line from the top to the bottom of the tree.

The thickneſs of the bark is entirely formed of ſtrata of theſe longitudinal fibres, which lie one over the other; each of theſe ſtrata is ſimilar to the exterior one, only the meſhes are ſmaller, and the fibres finer, in proportion as they are more interior, inſomuch that at laſt the meſhes are almoſt annihilated, and the fibres ſeem to lie quite parallel to each other.

There are ſome trees, however, where the meſhes are not viſible, and in which the fibres lie quite in a ſtrait direction. There are many other circumſtances in which they vary in different trees; in ſome the meſhes of each ſtratum correſpond with each other, diminiſhing gradually in ſize as they are more interior, and forming as it were ſo many conical cells.

We may, I think, conclude from what has been ſaid, that the bark is compoſed of ſeveral thin membranes, which extend over the whole exterior ſurface of the tree. The moſt exterior membrane is the rind; under this is what Duhamel calls the cellular coat; next to this the cortical ſtratum or true bark of the tree, which is formed of lymphatic veſſels ranged more or leſs in a reticular form, and of the vaſa propria interiora. The meſhes are ſo conſtituted as to form large cavities next the rind, and ſmall ones near the wood. Theſe cavities are filled with a parenchymous ſubſtance or the cellular tiſſue, which being continued from the wood to the rind, joins and unites the cortical ſtratum, and afterwards ſpreading on the outſide thereof, forms what has been termed the cellular coat.

## OF THE CELLULAR TISSUE.

We now proceed to give ſome account of the ſubſtance which fills up the vacant ſpaces that are left between the longitudinal fibres. It is called by Grew the parenchyma or pulp, by Malphigi, the veſicular tiſſue or web; both of them conſider it as formed of ſmall bladders or reticules, that are in contact with each other, lying in an horizontal poſition, or at right angles to the longitudinal fibres: they do not ſuppoſe them to be all of the ſame ſize, or even of the ſame figure: Grew compares it to the froth of beer or eggs. The fleſh of fruits conſiſts for the moſt part of this ſubſtance, very much filled with juice, though with conſiderable difference in it's organization. Be this as it may, the nature of this ſubſtance, it's form and ſtructure, are at preſent but very little known. It is floccoſe, and varies in colour in different ſpecies.

### OF THE VASA PROPRIA INTERIORA.

Beſides the lymphatic veſſels and the cellular ſubſtance, we find the juice veſſels, or vaſa propria, in the bark. In thoſe trees which are famous for medicinal virtues, they are uſually very large; they carry the milky juices of the ſumach, and in them is lodged the fineſt and higheſt-flavoured turpentine in all the kinds of pine. Dr. Hill thinks that a tree of that genus exhibits them beſt, and the more, as the turpentine which fills them may be perfectly diſſolved in ſpirit of wine. The pinus orientalis is the ſpecies in which theſe veſſels are moſt diſtinctly ſeen.

### OF THE BLEA.

This is that part of the tree which is forming into wood, and therefore lies between it and the bark, and may be ſeparated from them by maceration.

A longitudinal piece of the blea, when examined by the microſcope, exhibits a number of veſſels running parallel to each other, the interſtitial ſpaces being filled with a floccoſe, white, formleſs ſubſtance, of which Dr. Hill ſuſpects even the veſſels themſelves to be formed. Innumerable ſmall openings, or mouths, may be diſcovered in theſe veſſels, ſuited to imbibe the moiſture which is ſo eſſential to the life and health of plants. Theſe mouths cannot be well diſcerned, except when they are opened by the ſeaſon of the year, either before the firſt leaves of ſpring, or in the midſummer ſhooting time; though a ſmall quantity of moiſture will keep them open at that time, yet no quantity would be ſufficient at an improper ſeaſon.*

The blea is a zone more or leſs perfect, which lies under the bark, and covers or ſurrounds the wood, and is principally diſtinguiſhed from it by being leſs denſe. In ſome ſpecies the difference between the blea and the wood is very remarkable, in others it is leſs ſo.

The ancient botaniſts, ſtruck with the difference they obſerved between the wood and the blea, compared this ſubſtance to the fat in animals. Malphigi, Grew, and Duhamel conſider it as the wood not yet arrived to a ſtate of perfection. It is organized in a manner ſimilar to the wood, and poſſeſſing the ſame veſſels, diſpoſed nearly in the ſame manner. The juice veſſels of this part may be ſeparated from it by maceration; Dr. Hill ſays, that in this ſtate they appear perfect cylinders, with thick white coats, the ſurface perfectly uniform.

## OF THE WOOD.

When the bark and the blea is taken away, we come to the wood, which is a ſolid ſubſtance, on which the ſtrength of the tree depends, and which has been conſidered by naturaliſts as being to the tree what bones are to the animal. The wood, in a general view, may be conſidered as formed of ſtrata, which are incloſed one within the other; theſe ſtrata conſiſt of lignous fibres or lymphatic veſſels, the cellular web or tiſſue, vaſa propria, and what have been called the air veſſels. It is more difficult to inveſtigate the conſtruction of the wood than that of the other parts, becauſe the texture is in general much harder, and therefore not ſo eaſily ſeparated, requiring very long macerations, and many ſubjects, before one may be found fit for examination.

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* Hill's Conſtruction of Timber.

If we examine a tranſverſe ſection of almoſt any kind of wood, we ſhall perceive theſe ſtrata very clearly and ſenſibly diſtinguiſhed from one another. It has been generally ſuppoſed, that each of theſe is the product of one year's growth; though if we cut the ſame wood obliquely, we ſhall perceive that each of theſe ſtrata is compounded of ſmaller ones, which are, therefore, not ſo eaſy to diſcover as the larger. By macerating rotten pieces of trees, the wood may be divided into an immenſe number of leaves, or ſtrata, thinner than the fineſt paper.

If the foregoing ſtrata are examined in their detached ſtate by the microſcope, we ſhall find them to be compoſed of longitudinal fibres; ſome pieces of rotten wood, after maceration, will divide of themſelves into very fine longitudinal fibres; the exiſtence of theſe is further proved by the facility with which wood may be ſplit in the direction of theſe fibres. From hence we may collect, that the lignous ſtrata are formed of ſmall fibres or veſſels, collected together in faſcicles, like the bark: in ſome trees they are parallel to each other, in others they are diſpoſed more obliquely, croſſing and forming an irregular kind of network. There is great probability that this reticular diſpoſition exiſts in all trees, though it may be difficult to diſcover it in many on account of the ſineneſs of the meſhes, the hardneſs of the wood, and the ſameneſs of colour in the conſtituent fibres.

We are here only ſpeaking of the lymphatic veſſels or lignous ſibres of the wood, which exiſt in it as well as in the bark, though in different ſtates; for the lignous fibres are always harder and leſs flexible than the cortical ones. Malphigi thinks they differ in another particular, namely, that a juice or fluid iſſues from the cortical, while none is found in thoſe of the wood. In this it would appear from the obſervations of Duhamel, that he was miſtaken.

A tranſverſe ſection of wood generally appears formed of a number of rays proceeding from the corona to the bark, which are interſected at different diſtances by concentric circles, interſperſed with veſſels of varying magnitude: the variations in this ſtructure afford much pleaſure to the curious obſerver, and throw conſiderable light upon the nature and properties of timber; for it is by means of a variety of ſtrainers that different juices are prepared from the ſame maſs. Matter, conſidered as matter, has no ſhare in the qualities of bodies. It is from the arrangement of it, or the recipient forms given to it, that we have ſo many different ſubſtances. According to the modifications that theſe receive, we ſhall find the ſame light, air, water, and earth, manifeſting themſelves in one by a deadly poiſon, and in another by the moſt ſalubrious food. A lemon ingrafted upon an orange ſtock, is capable of changing the ſap of the orange into it's own nature, by a different arrangement of the nutritive juices. One maſs of earth will give life and vigour to the bitter aloe, to the ſweet cane, the cool houſe-leek, and the fiery muſtard, the nouriſhing grain, and the deadly night-ſhade.

The wood may be conſidered as compoſed of two parts, lignous and parenchymous. We have already treated of the former; the latter is that which is diſpoſed into rays running as it were between the lignous fibres, and interweaving with them; it originates either with the pith or corona. There is a very great diverſity in theſe radial inſertions, in ſome trees there are very few, while they abound in others; in ſome they are very fine, in others very thick. In texture they ſeem ſimilar to the blebs of the bark, only that here they are ſo crouded and ſtretched out as to appear like parallel threads, ſomething ſimilar to a net when drawn tight.

## OF THE CORONA.

Dr. Hill gives this name to that circle which ſurrounds the pith, and ſeparates it from the wood; although in his opinion it differs greatly from both, and in it's compoſition has no reſemblance to either. It is, according to him, the moſt important part in the whole vegetable fabric, by which the propagation and increaſe of the branches, buds, and ſhoots, is carried on. *

It has been uſual to ſuppoſe the pith of vegetables to be the part in which theſe wonderful ſources of increaſe reſides, but this is not the caſe; and he aſſerts, that ſo far from being prior to the other parts, it is in reality poſterior to ſome of them.

The

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* Hill on the Conſtruction of Timber, p. 55.

The corona is not ſo uniform as the other parts, nor is it conſtituted exactly ſimilar in all trees. It is placed between the pith and wood in all vegetables, forming a ring, whoſe outline is more or leſs regulated. The general circle is cellular, compoſed of blebs and veſſels, like the bark and the rind, and is perfectly ſimilar to them, only that at different diſtances oblong cluſters of different veſſels are placed amongſt it. Theſe cluſters are uſually eight or ten in number, and give origin to the angles of the corona. They are not uniform, or of one kind of veſſels, as in the bark, but each has two diſtinct ſorts, the exterior one anſwering to the blea, and the interior to the wood of trees; and within each of theſe are diſpoſed veſſels not unlike thoſe in the blea and wood, though often larger than they are found in thoſe parts.

Thus each cluſter is compoſed of all the eſſential parts of the ſucceeding branch, and the intermediate parts of the circle are abſolutely bark and rind; they are ready to follow and clothe the cluſter when it goes off in the form of a ſhoot, becauſe it will then need their covering and defence, though, in it's preſent incloſed ſtate, it does not. It is from this conſtruction that a tree is ready at all times, and in all parts, to ſhoot out branches, and every branch in the ſame manner to ſend out others; for the whole trunk, and the branch in all it's length, have this courſe of eſſential veſſels ready to be protruded out, and the proper and natural integuments as ready to cover them. In ſome trees theſe parts are more evident, in others more obſcurely arranged. Dr. Hill ſays, the bocconia, or parrot-wood of the Weſt-Indies, and the greater celandine, are proper ſubjects for opening this great myſtery of nature. On the corona and it's cluſters depend that property of vegetables, that they can be produced entire from every piece. Theſe cluſters follow the courſe of the other portions of the tree; they are, therefore, every-where; they are always capable of growing, and their growth, even in a cutting of the ſmalleſt twig, cannot produce a leaf or any other part of a vegetable alone, but muſt afford the whole, for they are complete bodies, and the whole is there waiting only for the opportunities of extenſion. For the knowledge we have of this part we are altogether indebted to Dr. Hill. It remains for future obſervers to confirm or diſprove his obſervations.

## OF THE PITH.

The pith is found in the center of every young ſhoot of a tree; it is large in ſome, leſs in others, but preſent in all. It is placed cloſe within the corona.

It ſeems to be nothing more than a congeries of the cellular tiſſue; it is generally found near the center of the tree, incloſed as it were within a tube; in general, the cells of the pith are larger than thoſe of the cellular tiſſue, with which, according to Duhamel, it communicates. For the rays which extend from the pith to the bark are, in his opinion, produced from it. Thus, though it may differ in name from the parenchymous parts of the bark, and the radial inſertions in the wood, yet it is of the ſame nature and texture, and is continuous with them; ſo that, according to this idea, the ſkin, the parenchyma, the inſertions, and the pith, are all one piece of work, filled up in divers manners with the veſſels.

The bark and the wood grow thicker every year, while the pith, on the contrary, grows more ſlender, ſo that in a branch of one year it is of a larger ſize than it is in the ſame branch when two years old, and ſo on. In very young branches, while in an herbaceous ſtate, the pith forms the greateſt part of it's ſubſtance; but when the fibres are ſtronger, the pith becomes leſs ſucculent, and ſurrounded with a tube of wood; when the branch is arrived to a certain age, it is ſo compreſſed as to be almoſt annihilated. In examining different branches that proceed from others in their firſt ſtate, a ſmall communication between the pith of the one and the other will be found; but this communication is generally entirely cloſed up in the ſecond or third year.* The cells of which the pith is formed are at firſt entirely one connected body; but as the plant grows up, it is often ſo broke and ruptured, as to remain no longer a continuous ſubſtance.

This, as well as many other particulars in the hiſtory of the pith, corroborates the opinion of Dr. Hill,† who thinks it is formed for the purpoſe of moiſtening the cluſters of the corona, and regulating it's extenſion; it has been ſuppoſed coeval with, or primordial to all the other parts, but he thinks it is poſtnate, and comes after them in the order of time, as well as in it's uſes. That exhaled air gives origin to it's blebs, and the thickneſs of the juices cloathing the bubble, gives it form and ſubſtance. The firſt ſeaſon is the time of it's greateſt uſe, and it immediately after begins to decay.

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* Duhamel Phyſique des Arbres, tom. 1, p. 38.

† Hill's Conſtruction of Timber, p. 66.

The pith has in general been repreſented as much more complex than it really is. It conſiſts of a range of bladders, lying one over the other. The membrane is ſimple, the outline ſingle; but as it is very difficult to procure it in this ſimple ſtate, it is often ſeen and repreſented under a variety of irregular, though pleaſing forms, which are occaſioned by the interſections of the outlines of the blebs, as ſeen one over another.

A cluſter in any part of the corona, protruding itſelf onward and outward in the growing ſeaſon,* carries a part of the circle out with it. The cluſter itſelf is a perfect piece of the wood and blea, and the bark which follows it out in it's progreſs perfectly cloaths it: thus is the firſt protruſion of the ſhoot made, but all this while there is no pith. The continuation of growth is made by the extenſion of all the parts obliquely upwards; in the courſe of this extenſion they hollow themſelves into a kind of cylinder, of the form of the future branch, and by this diſpoſition a ſmall vacancy is made in their center. This enlarges as they increaſe, and as it enlarges it becomes filled with the exudation of thoſe little bladders which remain and conſtitute the pith, fed from the inner coat of the pith, which already begins to form itſelf into a new corona. Grew ſeemed to think, that in ſome inſtances the pith was of poſterior growth to the other parts, and derived it's origin from the bark; and that the inſertions of the bark running in

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* Hill's Conſtruction of Timber, p. 99.

in between the rays of the wood, meet in the center, and conſtitute the pith.

## OF THE SAP VESSELS.

The moſt numerous and the largeſt apertures are generally to be found in the wood, which are perceived very diſtinctly in a tranſverſe ſection, in which the ends of the veſſels are ſeen as cut through by the knife. The ſcarlet oak of America is recommended as a proper object for exhibiting them. If a ſhort cylinder of a three years branch of this oak, a little macerated, be hollowed away with a chiſſel, we ſhall ſee what a large portion of the wood is occupied by theſe veſſels; they are thick and ſtrong, and it is eaſy, with ſome care and attention, to looſen ſeveral of them.

If a number of theſe, thus ſeparated, be put into a vial of rain water, and frequently ſhook for ſeveral days, ſome will at length be found perfectly clean, theſe are then to be put into ſpirit of wine, and when that has been two or three times changed, they will be in a condition to be viewed for underſtanding their ſtructure; another method of preparation has been already ſhewn in page 162.

Theſe are the veſſels which have been called by ſome writers air, by others tracheal veſſels. It is, however, to be remarked, that moſt of thoſe who have conſidered them as air veſſels, refer us to the tree while in a more herbaceous ſtate; in this caſe they ſay, that we ſhall find theſe parts filled with a fine ſpiral filament. As theſe veſſels are often to be found empty, they have been ſuppoſed to anſwer the purpoſes of lungs to the plant. Malphigi aſſerts, that if they are examined in winter, they often exhibit a vermicular motion, which aſtoniſhes the ſpectator.

Thoſe who ſuppoſe the corona to contain the whole ſtructure of the tree in miniature, and that it is the embryo of future ſhoots, ſuppoſe it to contain the veſſels proper for each part, a ſubject that muſt be left to the deciſion of future obſervers.

### OF THE VASA PROPRIA INTIMA.

Theſe are the only veſſels which remain to be ſpoken of. They are large, conſpicuous, and important; their natural place is in the blea, though they are ſometimes repeated in the wood and the corona. Their coats are thicker than thoſe of any other veſſels.* It is not difficult, after a ſucceſsful maceration, to ſeparate ſome of theſe veſſels from the blea; in this ſtate they appear perfect cylinders, with thick white coats, of a firm, ſolid, and uniform texture.

It has generally been ſuppoſed, that each of thoſe concentric circles, which are to be obſerved in the tranſverſe ſection of almoſt every tree, was the product of one year, or the quantity of wood added to the tree in that ſpace; here, however, Dr. Hill differs again from the general opinion.

From what has been ſaid we may deduce the following general ideas relative to the organization of trees. The moſt obvious and remarkable parts of a plant, or tree, are the root, the ſtem, the

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* Hill's Conſtruction of Timber, p. 83 and 85.

the branches, the leaves, the flower, and the fruit. The component parts of theſe diviſions are not complicated, they are ſimple when compared to thoſe of an animal, and this becauſe the offices of the vegetable are fewer than thoſe of the animal.

The interior part may be conſidered as conſiſting of lignous fibres, interſperſed with a vaſt number of bladders, which are here named the cellular tiſſue, the vaſa propria, and the ſap veſſels; though theſe are conſidered by ſome writers as mere air veſſels.

The lignous fibres are very fine tubes, proceeding nearly in a vertical direction from the top to the bottom of the tree; they are ſometimes parallel to each other, ſometimes they divaricate, and often leave oblong intervals or ſpaces. There is great reaſon for ſuppoſing them to be a ſpecies of lymphatic veſſels. The vacant ſpaces between theſe fibres are filled up by a veſicular membrane, lying in an horizontal direction, and which is called in this chapter the cellular tiſſue.

The vaſa propria are formed of lignous fibres, but differ from the foregoing in their ſize, and in the juices which they contain. In the part properly called the wood, we meet with the ſap veſſels; but as in ſome ſtates they ſeem as if they were formed of a ſilver-coloured ſpiral membrane, and are found without any juices, they have been ſuppoſed to be air veſſels, and called the trachea, making up an arterial ſyſtem, and ſupplying the place of the heart in animals.

The interior part of the tree may be further conſidered as divided into four principal concentric ſtrata, the bark, the blea, the wood, and the pith: to theſe Dr. Hill has added the corona. Whatever part of a plant we examine, we find theſe and no more. The root, it's aſcending ſtalk, and deſcending fibre, are formed of one, and not three different ſubſtances. Thus the whole vegetable is reduced to one entire body. And what appears in the flower to be formed of altogether diſtinct parts, will be found to originate in theſe.

The bark, which is the exterior covering of the tree, is divided into two parts, a thin outer rind, and a much thicker inner one. The exterior one ſeems to be little more than a fine film of irregular meſhes, the inner one compoſed of large blebs, leaving in ſome ſubjects large vacant ſpaces, which form it's vaſa propria. It is made up of ſeveral ſtrata, laying one over the other.

Next to this is the blea, which is of an uniform ſtructure. It is an imperfect wood, waiting only for the hand of time to be brought to perfection. The duration of the blea in this middle ſtate depends on the internal powers and ſtrength of the tree, being ſo much ſhorter as this is more vigorous.

The wood, including the corona, comes next; it differs in denſity and duration, both from the blea, the bark, and the wood. It is made up of ſtrong fibres. The life of the vegetable ſeems to reſide in it; from it all the other parts are produced. It ſhoots a pith inwards, and a blea and a bark outwards.

Every tree may be conſidered as conſiſting of numerous concentric ſtrata, or flakes, forming ſo many cones, inſcribed one within the other, and whoſe number is almoſt indefinite. The moſt exterior contain the rudiments of the bark, the more interior thoſe of the wood. In the germ they are gelatinous, by degrees they become herbaceous, and in proceſs of time it aſſumes the conſiſtency of wood. Thus the ſtem, the root, and the branch, may be conſidered as formed of a prodigious number of concentric vertical ſtrata, each compoſed of different faſcicles of fibres, which fibres are again formed of ſmaller ones. The ſpaces between theſe, and among the fibres, are filled up, interwoven with and connected by the cellular tiſſue, of which the radial inſertions are formed.

The ſtrata harden ſucceſſively one after the other; the moſt interior ſtratum is that which hardens firſt, this is then covered by another which is more ductile and herbaceous, and ſo on. From the extenſion in breadth the tree acquires bulk, from that in length it gains it's height. The ſtrata gradually diminiſh in ſize as they gain in length; from hence the conical figure of the root and ſtem, and branch. All the parts of the plant are the ſame, differing in nothing more than in ſhape and ſize. The roots are ſharp and pointed, that they may make their way more readily through the earth. The leaves are broad, that they may more effectually catch the moiſture from the atmoſphere, &c. When the root of a tree is elevated above, inſtead of being retained under the earth, it aſſumes the appearance of a perfect plant, with leaves and branches. Experiment ſhews that a young tree may have it's branches placed in the earth, and it's roots elevated in the air, and in that inverted ſtate it will continue to live and grow. The principal ſource of the phænomena of vegetation is the ſimplicity and uniformity of their organization.

The figures in Plate XXVII. XXVIII. XXIX. are portions of tranſverſe ſections of trees and herbs. The ſections were cut by Mr. Cuſtance, who firſt brought this art to perfection, and remains unrivalled as yet in theſe performances.

Fig. 1, Plate XXVII. a piece of an herb growing on dunghills, and known by the name of fat-hen; it is one of the ſpecies of orach. Fig. 2, a microſcopic view of the ſame. Fig. 3, a magnified repreſentation of a ſection of a reed that comes from Portugal. Fig. 4, the real ſize of the ſection.

Fig. 1, Plate XXVIII. a magnified view of a ſection of the althea frutex. Fig. 3, a ditto of the hazel. Fig. 5, a ditto from a branch of the lime-tree. Fig. 2, 4, 6, repreſent the real ſize of the ſections.

Plate XXIX. Fig. 1, a magnified view of a ſection of common cane. Fig. 2, one of the bamboo cane. Fig. 3, one of ſugar cane. Fig. 3, 4, 6, the real ſize of the ſections.

CHAP.

# CHAP. X.

## OF THE CRYSTALLIZATION OF SALTS, AS SEEN BY THE MICROSCOPE; TOGETHER WITH A CONCISE LIST OF OBJECTS.

CRYSTALLIZATION, in general, ſignifies the natural formation of any ſubſtance into a regular figure, reſembling that of natural cryſtal. Hence the phraſes of cryſtallized ores, cryſtallized ſalts, &c. and even the baſaltic rocks are now generally reckoned to be effects of this operation; the term, however, is moſt commonly applied to bodies of the ſaline kind; and their ſeparation in regular figures from the water, or other fluid in which they were diſſolved, is called their cryſtallization. If the word cryſtallization were to be confined to it's moſt proper ſenſe, as it ſeems to have been formerly, it could only be applied to operations by which certain ſubſtances are diſpoſed to paſs from a fluid to a ſolid ſtate, by the union of their parts, which ſo arrange themſelves, that they form tranſparent and regularly-figured ſigured maſſes, like native cryſtal; from which reſemblance the word cryſtallization has evidently been taken.*

But modern chemiſts and naturaliſts have much extended this expreſſion, and it now ſignifies a regular arrangement of the parts of any body which is capable of it, whether the maſſes ſo arranged be tranſparent or not. Thus opake ſtones, pyrites, and minerals, when regularly formed, are ſaid to be cryſtallized, as well as tranſparent ſtones and ſalts.

The opacity and tranſparency of ſubſtances are juſtly diſregarded, in conſidering whether they be cryſtallized or not; for theſe qualities are perfectly indifferent to the regular arrangement of the integrant parts of ſubſtances, which is the eſſential object of cryſtallization.

This being eſtabliſhed, cryſtallization may be defined, an operation by which the integrant parts of a body, ſeparated from each other by the interpoſition of a fluid, are diſpoſed to unite again, and to form ſolid, regular, and uniform maſſes.

To underſtand as much as we can of the mechaniſm of cryſtallization, we muſt remark,

1. That the integrant parts of all bodies have a tendency to each other, by which they approach, unite, and adhere together, when not prevented by an obſtacle.

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* Macquer's Dictionary of Chemiſtry, Art. Cryſtallization.

2. That in ſimple or little-compounded bodies, this tendency of integrant parts is more obvious and ſenſible than in others more compounded: hence the former are much more diſpoſed to cryſtallize.

3. That although we do not know the figure of the primitive integrant molecules of any body, we cannot doubt but that thoſe of every different body have a conſtantly uniform and peculiar figure.

4. That theſe integrant parts cannot have an equal tendency to unite indiſcriminately by any of their ſides, but by ſome preferably to others, excepting all the ſides of an integrant part of a body be equal and ſimilar; and probably the ſides, by which they tend to unite, are thoſe by which they can touch moſt extenſively and immediately.

The moſt general phænomena of cryſtallization may be conceived in the following manner:

Let a body be ſuppoſed to have it's integrant parts ſeparated from each other by ſome fluid; if a part of this fluid be taken away, theſe integrant parts will approach together; and as the quantity of intervening fluid diminiſhes, they will at laſt touch and unite. They may alſo unite when they come ſo near to each other, that their mutual tendency ſhall be capable of overcoming the diſtance betwixt them. If, beſides, they have time and liberty to unite with each other by the ſides moſt diſpoſed to this union, they will form maſſes of a figure conſtantly uniform and ſimilar. For the ſame reaſon, when the interpoſed fluid is haſtily taken away, ſo that the integrant parts ſhall be approximated, and be brought into contact before they have taken the poſition of their natural tendency, then they will join confuſedly by ſuch ſides as chance preſents to them; they will, in ſuch circumſtances, form ſolid maſſes, whoſe figures will not be determinate, but irregular and various.

Different ſalts aſſume different figures in cryſtallization, and are, by this means, eaſily diſtinguiſhed from one another. But beſides the large cryſtals produced in this way, each ſalt is capable of producing a very different appearance of the cryſtalline kind, when only a drop of the ſaline ſolution is made uſe of, and the cryſtallization viewed through a microſcope. For our knowledge of this ſpecies of cryſtallization we are indebted to Mr. Henry Baker, who was preſented by the Royal Society with a gold medal for the diſcovery, in the year 1744. Theſe microſcopical cryſtals he diſtinguiſhes from the larger ones by the name of configurations; but this term ſeems inaccurate, and the diſtinction may be properly preſerved by calling the large ones the COMMON, and the ſmall ones the MICROSCOPICAL cryſtals of the ſalt.

It has not yet been ſhewn by any writer on the ſubject, why ſalts ſhould aſſume any regular figure, much leſs why every one ſhould have a form peculiar to itſelf. Sir Iſaac Newton endeavoured to account for this, by ſuppoſing the particles of ſalt to be diffuſed through the ſolvent fluid, at equal diſtances from each other; and that then the power of the attraction between the ſaline particles could not fail to bring them together in regular figures, as ſoon as the diminution of heat ſuffered them to act on each other.* But it is certain ſome other agent muſt be concerned in this operation beſides mere attraction, otherwiſe all ſalts would cryſtallize in the ſame manner. Others have, therefore, had recourſe to ſome kind of polarity in the particles of each ſalt, which determined them to arrange themſelves in ſuch a certain form; but unleſs we give a reaſon for this polarity, we only explain cryſtallization by itſelf. One thing ſeems to have been overlooked by thoſe who have endeavoured to inveſtigate this ſubject, namely, that the ſaline particles do not only attract one another, but they alſo attract ſome part of the water which diſſolves them.

Did they only attract each other, the ſalt, inſtead of cryſtallizing, would fall to the bottom as a powder; whereas, a ſaline cryſtal is compoſed of ſalt and water, as certainly as the body of an animal is compoſed of fleſh and blood, or a vegetable of ſolid matter and ſap; if a ſaline cryſtal is deprived of it's aqueous part, it will as certainly loſe it's cryſtalline form as if it was deprived of the ſaline part. It is, therefore, not improbable, that cryſtallization is a ſpecies of vegetation, and is accompliſhed by the ſame powers to which the growth of plants and animals are to be aſcribed. Some kinds of cryſtallization reſemble vegetation ſo much, that we can ſcarce avoid attributing them to the ſame cauſe.

It has been imagined, that all the great operations in nature may be reduced to two principles, thoſe of cryſtallization and organization; but that often they are ſo concealed as to be inviſible.

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* Encyclopædia Britannica, p. 2329.

viſible. Hence cryſtallized ſubſtances have been often miſtaken for organized ones, and vice verſa. They differ, however, eſſentially in their growth and origin. Organized beings ſpring from a germ, in which all the eſſential parts are concentrated, and they grow by intuſception; whereas cryſtallized ſubſtances increaſe by the ſucceſſive appoſition of certain molecules, of a determined figure, which unite in one common maſs. Thus cryſtallized beings do not grow, properly ſpeaking; though their ſubſtance is augmented, they are not preformed, but formed daily.

We have already ſhewn, page 163, how to prepare the various ſalts for microſcopical obſervations. The beautiful cryſtallizations repreſented in Pl. XXX. and XXXI. were produced in the manner there deſcribed.

Fig. 2, Plate XXX. ſhews the microſcopical cryſtals of nitre. Theſe ſhoot from the edges with very little heat, in flattiſh figures, of various lengths, and exceedingly tranſparent, the ſides nearly parallel, though rather jagged, and tapering to a point; after a number of theſe are formed, they often diſſolve under the eye, and diſappear entirely; but in a little time new ſhoots will puſh out, and the proceſs go on afreſh. Beautiful ramifications are formed round the edge, and many regular figures are to be obſerved in different parts of the drop. Fig. 2 is the real ſize of the drop.

Fig. 3, Plate XXX. is a drop of diſtilled verdigreaſe, as it appeared when viewed by the microſcope. There is a difference in the appearance from this ſubſtance, according as the time of the application is nearer to or more diſtant from that in which the ſolution was made.

Fig. 1, Pl. XXXI. repreſents the microſcopical cryſtals of ſalt of wormwood. The ſhootings from the edges of this ſolution are often very thick in proportion to their length, their ſides full of notches, the ends generally acute; many ſpear-like forms are alſo to be obſerved, as well as little cryſtals of a variety of figures.

Fig. 2, Plate XXXI. the ſalt of amber. The ſhootings of this ſalt are highly entertaining, though the proceſs is very ſlow; many ſpicula ſhoot from the edge towards the middle of the ſolution, and from the pointed ends of the ſpicula, a great variety of diverſified branches may be obſerved, variouſly divided and ſubdivided, and forming at laſt, ſays Mr. Baker, a winter ſcene of trees without leaves.

Salt of hartſhorn, Fig. 3, Plate XXXI. This ſalt ſhoots out from the edge of the drop into ſolid, thick, and rather opake figures; from theſe it often ſhoots into branches of a rugged appearance, ſimilar to thoſe of ſome ſpecies of coral.

Fig. 4, Pl. XXXI. repreſents the configurations of ſal ammoniac. Theſe form a moſt beautiful object in the microſcope: a general idea may be more eaſily formed, by conſidering the figure here exhibited, than by any verbal deſcription.

## A CONCISE LIST OF OBJECTS FOR THE MICROSCOPE.

The ſhort liſt here preſented to the reader muſt, from the nature of the ſubject, be very imperfect; for the whole of the animal, vegetable, and mineral kingdoms, with all their numerous ſub-diviſions, furniſh objects for the microſcope; and there is not one of them that, when properly examined, will not afford inſtruction and entertainment to the rational inveſtigator of the works of creation. The Syſtema Naturæ of Linnæus may therefore be conſidered as a catalogue of univerſals for microſcopic obſervation, each of which involves a variety of particulars. The liſt here given can be conſidered as little more than a directory, to point out to thoſe who have only begun to ſtudy this part of natural hiſtory, a few of thoſe objects which merit their attention, and which, from their beauties, may incite them to purſue the ſtudy with greater ardor.

"Thoſe who rightly conſider natural things, will find them a ſhadow of heavenly things, a ſchool in which God is the teacher, and all the objects of ſenſe in heaven and earth, and under the earth, are as the letters of an univerſal language, in which all nations have a common intereſt. The Creátor himſelf has made this uſe of it, revealing his will by it, and referring man to it for inſtruction. From hence the univerſal agreement between nature and revelation. Hence, alſo, he that can underſtand God as the fountain of truth, and the Saviour of men in the holy ſcriptures, will be better diſpoſed to underſtand and adore Him as the fountain of power and goodneſs in the natural creation. Whereſoever we go in divinity, the true philoſophy will follow us as a faithful witneſs, and ſhew that the world was made, as the ſcriptures were written, for our inſtruction; and find the creation of God is the ſchool of chriſtians, if they uſe it aright."*

## OF OPAKE OBJECTS.

Ores and minerals afford an immenſe variety of very beautiful and ſplendid objects. From amongſt theſe the obſerver may ſelect the peacock, or coloured copper ore, green cryſtallized ditto, lead ore, cryſtallized ditto, cryſtals of lead, ſmall grained marcaſites, coloured mundic, cinnabar, native ſulphur, needle and other antimony, moſs copper, &c. A mixture of ſmall pieces of ores, &c. of different kinds, produces a pleaſing effect. Sands, in general, exhibit ſomething not diſcoverable with the naked eye. Sand from the ſea-ſhore is often intermixed with minute ſhells, particularly that from Rimini, in Italy. Mr. Walker has publiſhed a ſpecimen of the ſmall microſcopic ſhells which are found on our own coaſt. From this work we learn, that there are ſhell-fiſh as ſmall as the minuteſt inſects, and poſſeſſed of beauties, of which we can form no conception till we have ſeen them. Mr. Walker's work is entitled, "A Collection of the minute and rare Shells found on the Sea-ſhore near Sandwich." There is a ſand from Africa full of ſmall garnets. The ketton, or kettering ſtone, is a pleaſing object; when examined by the microſcope, we find the grain of it very different from that of other ſtones, being compoſed of innumerable minute balls, which barely touch each other, and yet form a ſubſtance much harder than free-ſtone; the grains are, in general, ſo firmly united together at the points of contact, that it is hardly poſſible to ſeparate them without breaking one or both of the grains. See Hooke's Micrographia.

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* Jones's Lectures on the Figurative Language of the Holy Scriptures.

INSECTS of all kinds, both foreign and domeſtic, are pleaſing objects; but as the foreign ones are not ſo eaſily met with, I ſhall mention but a few of them, confining myſelf principally to thoſe of this country. Among the exotic inſects none appear more beautiful in the microſcope than the curculio imperialis, Brazil, or diamond beetle; the bupreſtis ignita, a large beetle from China; the meloe veſicatorius, bliſter-fly, or cantharis of the ſhops; ſeveral ſpecies of locuſts, graſshoppers, &c. Among the Engliſh beetles we may reckon the ſcarabæus auratus, or roſe chaffer, ſcarabæus nobilis, ſcarabæus horticola, ſilpha aquatica, caſſida nobilis and nebuloſa. Coccinella, or lady-cow; of theſe there are great variety, both in ſize and colours, ſome red and black, others black and red, and ſome yellow and black. Chryſomela, graminis-faſtuoſa, nitidula, ſericea, melanopa, aſparagi, vide Plate XX. Fig. 2. Curculio-frumentarius, lapathi, betuta, nucum, ſcrophularia, argenteus, a beautiful little inſect reſembling the diamond beetle, but in miniature; curculio albinus, very beautiful, but ſcarce in this country. Leptura aquatica, theſe are of various colours, as blue, purple, bronze, and crimſon. Arcuata arictis, very common, and is often called the waſp beetle. Cicendela campeſtris, on dry banks. Carabus nitens, found in Yorkſhire, a beautiful inſect, many ſmall carabi. Gryllus, gryllo talpa, or mole cricket; this inſect, and the graſshoppers, are many of them too large to be obſerved at one view, but the head, fore and hind feet, elytra, &c. viewed ſeparately, are fine objects. Cicada, ſanguinolenta, nervoſa, interrupta, notonecta ſtriata, minutiſſima, head and claws of the nepa cinerea, or water-ſcorpion, and the whole variety of cimeces, or field bugs. The wings of butterflies and moths, the chryſalis of the common white butterfly, is extremely fine.

I wiſh it were in my power to invite the reader to conſider the pupa ſtate of theſe inſects, as he would find them intereſting in various points of view. Perhaps the following paſſage from an ingenious writer may have this effect.

"Some of theſe creatures crawl for a time as helpleſs worms upon the earth, like ourſelves; they then retire into a covering, which anſwers the end of a coffin, or a ſepulchre, wherein they are inviſibly transformed, and come forth in glorious array, with wings and painted plumes, more like the inhabitants of the heavens than ſuch worms as they were in their former ſtate. This transformation is ſo ſtriking and pleaſant an emblem of the preſent, intermediate, and glorified ſtate of man, that people of the moſt remote antiquity, when they buried their dead, embalmed and incloſed them in an artificial covering, ſo figured and painted, as to reſemble the caterpillar in the intermediate ſtate; and as Joſeph was the firſt we read of that was embalmed in Egypt, where this cuſtom prevailed, it was probably of Hebrew original."

The eggs of moths and butterflies, particularly the phalæna neuſtria, vide Plate X. Fig. 1 to 5. The bodies and heads of many libellulæ.

Many of the ichneumon flies, ſpheges and waſps, head of the hornet, ſting of ditto, collectors of the bee, many ſorts of muſcæ, or flies with two wings, eſpecially thoſe whoſe bodies are highly coloured; acari, or ticks; phalangium cancroides, vide Plate XVIII. Fig. 1 and 6. Some ſpiders, but the eyes of all; the oniſcus or wood louſe, julus, and ſcolopendræ.

The feathers of peacocks, and many other birds, have a grand effect when viewed in the opake microſcope, as have alſo ſome ſpecies of ferns, moſſes, and wood cut tranſverſely. Madrepores, millepores, ſponges, corralines, &c. exhibit wonderful appearances, not diſcernible to the naked eye. Parts of echini or ſea eggs, ſpines of ditto; theſe may alſo be cut tranſverſely, to ſhew their conſtruction. Minute ſhells diſſected, ſkin of many ſpecies of fiſh, particularly the lump fiſh, Plate XVIII. Fig. 2. Soal, and the raſp fiſh from Otaheite, alſo the ſkins of ſnakes, lizards, guanas, &c. &c. An endleſs variety will be diſcovered in ſeeds.

The exterior form, and even the internal ſtructure of the generality of vegetable ſeeds, have been ſuppoſed by ſome ſo much alike in the ſeveral kinds, and of ſo little curioſity and beauty in the whole, that they have ſcarcely been regarded by the curious; but when nearly examined, with the help of microſcopes, they are found to be worthy of a greater attention; thoſe which appear moſt like to one another, when viewed by the naked eye, often proving as different when thus examined, in their ſeveral forms and characters, as the different genera of any other bodies of the creation. If their external forms carry all this variety and beauty about them, their internal ſtructure, when laid open by different ſections, appears yet more admirable.

The ſeed of the muſk ſcabious is amazing in it's ſhape and ſtructure; it reſembles in figure an octagonal vaſe, with a ſcalloped brim; the whole is bell-faſhioned, having ribs or diviſions, which run down from the mouth of the vaſe, and thence becoming narrower, form the bottom. Between theſe ribs, down to the beginning of the narrow part, it is clear, though not wholly tranſparent, and from thence to the bottom the ribs are hairy. This vaſe contains a ſeed, which is like a peſtle ſtanding in a mortar. The peſtle ſtands looſe in an octagonal caſe, but the narrowneſs of the mouth of this vaſe hinders the peſtle's being drawn out, becauſe it's extremity within is rounded, and thicker than any other part of it. From it's upper end there ariſe five ſpiculated areſtæ, or awns, whoſe little thorns are directed upwards, and are thereby prepared to cauſe the ſeed to recede from any thing that might injure it on being touched. The baſon, from which theſe ariſtæ ariſe, is of a fine green colour, and they are of an elegant ſhining brown.

The ſeed of the great maple, which we commonly, but improperly, call the ſycamore tree, conſiſts of a pod and it's wing; two of theſe grow upon a pedicle, with the pods together, which makes them reſemble the body of an inſect with it's expanded wings: the wings are finely vaſculated, and the pods are winged with a fine white down, reſembling ſilk: this contains a round compact pellet, covered with a brown membrane, that ſticks very cloſely to it. When this is pulled off, inſtead of diſcerning a kernel, as in other ſeeds, there appears an entire green plant, folded up in a moſt ſurprizing manner. The pedicle of this is about two-eighths of an inch long, and it's ſeminal leaves of about ſix-eighths each; between theſe the germina of the next pair of leaves are plainly viſible to the naked eye, but with a microſcope they are ſeen with the greateſt beauty and perfection. Theſe, and a number of ſuch other beauties in this part of the creation, are deſcribed at large by Dr. Parſons, in his work entitled, "A Microſcopic Theatre of Seeds." Moſt kinds of ſeeds ſhould be prepared for a microſcopical examination, by ſteeping them in warm water till their coats are ſeparated, and their ſeminal leaves may then be opened without laceration. But ſeeds, while dry, and without any preparation, are of an almoſt infinite variety of ſhape, and afford a number of pleaſing objects for the microſcope.

## TRANSPARENT OBJECTS.

We may ſelect from the elytra, or upper wings of beetles, many beautiful objects; the conſtruction of theſe will be found to differ very much; the membranaceous wings, as in the ſcarabæus ſolſtitialis, or ſmall cock-chaffer; blatta americana, or cock-roach; all the grylli, as locuſts, graſshoppers, &c. Among the cicadas, the elytra of the nervoſa are the moſt elegant, the nerves are elevated, and curiouſly ſpotted with brown. The elytra of the cimeces, or field bugs, which are a very numerous tribe, afford a great variety of objects; we may ſelect from theſe, as the moſt beautiful, the elytra of the cimex baccarum, ſtriatus, Plate XX. Fig. 2. The elytra of the fulgora candelaria, from China, differs eſſentially from all others.

The under, or more tranſparent wings of beetles excite our attention even more than the upper, or cruſtaceous ones; for whether we conſider the delicacy of their texture, the great weight that many of them are calculated to ſuſtain in the air, or the very curious manner in which they fold them up under the upper caſe, their mechaniſm muſt aſtoniſh and delight us; no two genera will be found alike, though every individual of the ſame genus will be exact; the wing of the forficula, or earwig, Plate XIX. Fig. 1, is an elegant ſpecimen of the manner of their folding; this wing folds under a caſe not one-eighth of it's ſize.

The under wing of the blatta orientalis, a beetle common in moſt kitchens, appears to unite the elytra and tranſparent wings, partaking in ſome degree of both.

Among the membranaceous or more tranſparent-winged inſects, the variety is endleſs, each genus differing eſſentially from the other, ſome appearing full of membranes, or nerves, curiouſly diſpoſed; others, again, with ſcarce any, like a clear piece of talc, or iſinglaſs; ſome exhibit a curious ground-work of points, which, on cloſe examination, prove ſhort hairs, while the nerves of others are furniſhed with little ſcales, or feathers, as in ſome ſpecies of the gnat. The wings of many muſcæ are coloured with black, brown, and white, in clouds, ſpots, ſtripes, &c. &c.

The libellulæ, or dragon-flies, alone afford a great variety, not only in form, but colour; theſe are all furniſhed with numerous and very ſtrong nerves, adapted to the velocity of their flight; the wings of the ephemera, or May flies, are much more delicate, theſe flies reſt with their wings erect. The phryganeæ differ very much from the foregoing, and alſo from one another; their under wings fold, and the upper ones are of a ſtronger texture, many of them ſo much reſembling ſmall moths as not eaſily to be diſtinguiſhed from them: theſe are all found in the vicinity of ponds or marſhy places. In the hemerobii a wonderful degree of elegance is exhibited in the diſpoſition of the nerves, which compoſe their wings, each nerve being adorned with hair in a beautiful manner; there are many ſpecies of theſe flies equally beautiful, a ſpecimen is given in Plate XIII. Fig. 1. The ichneumon fly has four tranſparent wings, the inferior ones ſmaller, and more delicate than the ſuperior; the tube through which the female depoſits it's eggs, is an additional object well worth attention. The wings of waſps are folded longitudinally, the wings of the large bee are very curious. Gnats in general, and the various ſpecies of tipulæ, together with the clouded and variegated wings of the muſcæ, tabani, &c. increaſe the catalogue beyond the power of enumeration; in ſhort, there is not a wing but has it's particular beauties, and will amply repay the attentive obſerver. The current ſphinx moth connects the tranſparent and farinaceous wings partaking of both, and the white plumed, and many plumed moths, exhibit wings totally different from all the reſt; many other ſmall moths furniſh wings ſufficiently tranſparent for obſervation, the fringe or edges being remarkably beautiful.

Many ſmall inſects that are not too opake, may be viewed and examined as tranſparent objects; as ſome of theſe have been particularly noticed by the early microſcopic writers, it will be neceſſary to give ſome account of them, as without it the work might be deemed incomplete. Every one is acquainted with the agility and blood-thirſty diſpoſition of the flea, of the caution with which it comes to the attack, and the readineſs with which it avoids purſuit. It belongs to the claſs aptera, has two eyes, ſix feet, particularly conſtructed for leaping, the feelers are filiform, the roſtrum is inflected, ſetaceous, and armed with a ſting; the belly is compreſſed. This creature is produced from eggs, which they depoſit on the animals that afford them food, or affix them to the wool of blankets, rugs, &c. of theſe eggs are hatched white worms, which adhere cloſely to the body of the animal, or other ſubſtance on which they are produced; in a fortnight they come to a tolerable ſize, and are very lively and active; but if they are touched at this time, they roll themſelves up in a ball. After about eleven days from the time of their being hatched, they ſeek a place to hide in, and if viewed by a microſcope, will be found weaving a covering or bag, in which they aſſume the pupa ſtate, where they continue from nine days to a fortnight, when having acquired ſufficient ſtrength, they burſt from their confinement, perfectly formed, and armed with powers to diſturb the peace of an emperor.

The flea when examined by the microſcope is not an unpleaſing object: it is difficult, however, to obtain ſuch a view of it as will diſplay the mechaniſm and apparatus belonging to the head. Theſe parts are but imperfectly repreſented in the celebrated drawing of Dr. Hooke. The neck is long, finely arched, and much reſembles the tail of a lobſter; the body is covered all over with a ſuit of ſable armour, formed of a hard ſhelly ſubſtance, curiouſly jointed and folded over one another, and yet yielding to all the nimble motion of the little animal: the edges of the ſcales are curiouſly ſet with ſhort ſpikes or hairs: it has two ſharp eyes to look before it leaps, for which purpoſe it's legs are excellently adapted, for the joints are ſo conſtructed that it can fold them up as it were, and when it leaps, ſpring them out all at once, whereby it's whole ſtrength is exerted, and the body often raiſed two hundred times it's own diameter; there are ſeveral joints in the legs; they are alſo very hairy, and terminated by two long hooked ſharp claws; the two fore legs are placed very near the neck, and often conceal the proboſcis from our view, the other four join all at the breaſt: the flexure of the two fore ones is contrary to that of the hinder ones: the proboſcis, or ſucker, with which it penetrates the ſkin, is placed at the end of the ſnout, and is not eaſily ſeen, except the two fore legs are firſt removed; in it are included a couple of darts or lancets, which, after the proboſcis has made an entrance, are thruſt farther into the fleſh, and make the blood flow from the adjacent parts, and occaſion that round red ſpot, with a hole in the center of it, called a flea bite.

The bed bug is another nauſeous inſect, "that intrudes upon the peace of mankind, and often baniſhes that ſleep which even anxiety and ſorrow permitted to approach: the night is the ſeaſon when the bed bug iſſues from it's retreat to make it's depredations: by day it lurks in the moſt ſecret parts of the bed, takes the advantage of every chink and cranny to make a ſecure lodgement, and contrives it's habitation with ſo much art, that ſcarce any induſtry can diſcover it's retreat: but when darkneſs promiſes ſecurity, it then iſſues from every corner of the bed, drops from the teſter, and crawls from behind the arras, and travels to the unhappy patient, who vainly wiſhes for reſt and refreſhment."

Theſe inſects are as diſagreeable from their nauſeous ſtench, as their unceaſing appetites. Linnæus thinks that they are not originally of European growth, but were imported from ſome other country. It has two brown ſmall prominent eyes, two antennæ, and a crooked proboſcis, which lies cloſe under the breaſt. Inſtead of wings, we find on the firſt ring of the belly, two flat pieces which entirely cover it, and extend towards the ſides. Theſe plates, the trunk and the head, are amply ſet with hairs. The proboſcis is divided tranſverſely into four parts, which are probably ſo many articulations; this piece is beſt ſeen on the underſide of the bug. It has ſix legs, each of which has three joints; the ſkin is chagrined, and the ſeparation of the rings uſually marked by a ſmooth ſhining band. On the belly, at a ſmall diſtance from the edge, you may perceive a ſet of circular ſpots, two on each ring, except the laſt; theſe are the ſpiracula. Examined internally we find one large artery, a ſtomach, and inteſtines. The inſtant it perceives the light it endeavours to gain it's habitation, and ſeldom fails in making good it's retreat.

Of the louſe. Various as are the antipathies of mankind, all ſeem to unite in their diſlike to this animal, and to regard it as their natural and moſt nauſeous enemy. "Whenever wretchedneſs, diſeaſe, and hunger, ſeize upon man, the louſe ſeldom fails to add itſelf to the tribe, and to increaſe in proportion to the number of his calamities."

When the human louſe is examined by the microſcope, it's deformity fills us with diſguſt. In the head we may diſtinguiſh two fine black eyes, near this are the two antennæ: the fore part of the head is rather long, the hinder more obtuſe or rounder;

there is a ſmall part that projects from the noſe or ſnout, this ſerves as a ſheath or caſe to the proboſcis, which the creature thruſts into the ſkin to draw out the blood and humours which are it's deſtined food, for it has no mouth which opens in the common way.

This proboſcis has been eſtimated to be ſeven hundred times ſmaller than a hair, and is contained in another caſe within the firſt, and can be drawn in or thruſt out at pleaſure: the ſkin is hard and tranſparent. From the under ſide proceed ſix legs, each of which has five joints, and terminates in two unequal hooked claws, theſe it uſes as we would a thumb and finger; there are hairs between the claws, as well as all over the legs; the body finiſhes in a cloven tail, which is generally covered, and partly concealed by hairs.

From the extreme tranſparency of it's ſkin, many of it's internal parts may be ſeen, as the various ramifications of the veins and arteries, and the periſtaltic motion of the guts. When the louſe feeds, the blood is ſeen to ruſh like a torrent into the ſtomach, and it's greedineſs is ſo great, that the excrement contained in the inteſtines is ejected at the ſame time, to make room for this new ſupply. There is ſcarce any animal that multiplies ſo faſt as this unwelcome intruder, the moment it is excluded from the egg it begins to breed.

It would be endleſs to deſcribe the various creatures which go under the name of lice, and ſwarm upon every part of nature. The reader who wiſhes for a more particular account of thoſe which infeſt various animals, would do well to look into Rhedi's Treatiſe de Generatione Inſectorum.

The ſpider is another inſect which is often examined by the microſcope, and certainly affords much matter for obſervation. "Formed for a life of rapacity, and incapable of living but by blood, all it's habits are calculated to deceive and ſurprize; it ſpreads toils to entangle it's prey; it is endued with patience to expect it's coming, and is poſſeſſed of arms and ſtrength to deſtroy it when fallen into the ſnare.

"——— To heedleſs flies the window proves
A conſtant death; where, gloomily retired,
The villian ſpider lives, cunning and fierce,
Mixture abhorr'd; amid a mangled heap
Of carcaſes, in eager watch he ſits,
O'erlooking all his waving ſnares around.
Near the dire cell the dreadleſs wanderer oft
Paſſes, as oft the ruffian ſhews his front;
The prey at laſt enſnar'd, he dreadful darts
With rapid glide along the leaning line;
And, fixing in the wretch his cruel fangs,
Strikes backward grimly pleas'd: the flutt'ring wing
And ſhriller ſound declare extreme diſtreſs,
And aſk the helping hoſpitable hand."

The eyes of the ſpider are a very beautiful microſcopic object, viewed either as tranſparent or opake; they have generally eight, two on the top of the head, that look directly upwards; two in the front, a little below the foregoing, to diſcover what paſſes before it; and on each ſide a couple more, one whereof points ſideways forward, the other ſideways backward; ſo that it can ſee almoſt all round it. They are immoveable, and ſeem to be formed of a hard, tranſparent, horny ſubſtance. The number of eyes is not the ſame in all the ſpecies of the ſpider. They have eight legs, with ſix joints, thickly beſet with hairs, and terminating in two crooked moveable claws, which have little teeth like a ſaw; at a ſmall diſtance from theſe claws, but placed higher up, is another, ſomewhat like a cock's ſpur, by the aſſiſtance of which it adheres to it's webs; but the weapon wherewith it ſeizes and kills it's prey is a pair of ſharp crooked claws, or forceps, placed in the fore-part of the head. They can open or extend theſe pincers as occaſion may require; when undiſturbed, they ſuffer them to lie one upon another. Mr. Leeuwenhoeck ſays, that each of theſe claws has a ſmall aperture, or ſlit, through which he ſuppoſes a poiſonous juice is injected into the wound it makes.

The exuvia of the ſpider, which may be found in cobwebs, being tranſparent, is an excellent object; and the fangs, or forceps, may be eaſier ſeparated from it, and examined with more exactneſs than in a living ſpider. The contexture of the ſpider's web, and their manner of weaving them, have been diſcovered by the microſcope. The ſpider is ſupplied with a large quantity of glutinous matter within it's body, and five dugs, or teats, for ſpinning it into thread. This ſubſtance, when examined accurately, will be found twiſted into many coils, of an agate colour, and which, from it's tenacity, may be eaſily drawn out into threads. The five teats are placed near the extremity of the tail; from theſe the aforeſaid ſubſtance proceeds; it adheres to any thing it is preſſed againſt, and being drawn out, hardens in the air. The ſpider can contract or dilate at pleaſure the orifices through which the thread is drawn. The threads unite at a ſmall diſtance from the body, ſo that thoſe which appear to us ſo ſine and ſingle, are notwithſtanding compoſed of five joined together, and theſe are many times doubled when the web is in formation.

The gnat is a beautiful object for the microſcope. We have already noticed the curious manner in which they diſpoſe their eggs upon the ſurface of the water. Theſe, as they come to maturity, ſink deeper. There is no ſpecies of inſect more troubleſome to mankind than the gnat: others give more pain with their ſtings, but it is only by accident we are ſtung by them; but the gnats thirſt for our blood, and follow us in whole companies for it. There are many marſhy places in our country, where the legs and arms of the inhabitants are kept ſwelled all the ſummer by the biting of theſe inſects: in many other countries they are yet more troubleſome than with us. It is one of thoſe inſects which paſs through two ſtates of life, ſeemingly quite oppoſed to each other; in one condition ſwimming in the water like fiſh, in the other becoming like the birds, inhabitants of the air.

From the egg proceeds the larva, in which ſtate it is moſt happily ſuited to ſhew the ſeveral operations of life; for a moderate magnifying power will diſcover what paſſes within it's tranſparent body. It has a large ſcaly head, with two large antennæ, beſides ſeveral hairy parts, and articulated briſtles near the mouth, which are in continual motion. If the worm be diſſected, the feet of the gnat may be found folded up in the diviſions of the thorax ; the abdomen is divided into eight rings, from the edges of each of which three or four briſtles proceed. The tail is divided into two parts, of very different forms ; by one of theſe it can ſteer itſelf any way, in the other we may diſcover two pulmonary tubes, through which the inſect breathes. The larva has a power of moiſtening the tail with an oleaginous liquor, by which means it can ſuſpend itſelf on the ſurface of the water. On agitating the water, the worms deſcend with precipitation to the bottom ; but they ſoon return to the ſurface, to breathe the air through the tube that is annexed to their tail. They paſs from this ſtate into that of the pupa, which is the gnat incloſed in a thin ſkin, under which it is formed and ſtrengthened, the organs of reſpiration are changed, breathing in this ſtate through a couple of horns, which are placed near the head, keeping itſelf rolled upon the ſurface of the water, though on the leaſt motion it deſcends, unrolling itſelf, aided by the oars near the tail.

From the ſpoils of the pupa, a little winged inſect proceeds, whoſe every part is active to the laſt degree, and whoſe whole ſtructure is the juſt object of our admiration. It's head, adorned with feathers, is a fine microſcopic object ; but the proboſcis may be deemed one of the moſt curious inſtruments in the inſect creation. It conſiſts of a ſcaly ſheath ; at about two-thirds from the end of this there is an aperture, through which it darts four pieces ; one of theſe is, however, no more than the caſe in which the others lie concealed.

The proboſcis of the gnat conſiſts of a great number of extremely delicate pieces, all concurring to one purpoſe; this is the inſtrument with which it ſtrikes the fleſh, and ſucks the blood of animal bodies. The only part exhibited to the naked eye is the ſheath, which contains all the other pieces. The ſheath is a cylindric tube, which is ſlit in ſuch a manner, that the inſect can ſeparate it from the dart, and bend it more or leſs in proportion as the dart is plunged into the wound. From this tube the ſting is darted, which conſiſts of five or ſix blades or lancets, lying one over the other; ſome of theſe are ſharpened like a two-edged ſword, while others are barbed, and have a vaſt number of cutting teeth. When this bundle of blades is introduced into a vein, the blood riſes up the blades as ſo many capillary tubes. The moment the gnat lances it's dart into the fleſh, two or three drops of a fluid are inſinuated by it into the wound. It is this fluid which is ſuppoſed to cauſe thoſe inſupportable itchings that we feel when ſtung by this little creature.

Plate XVI. Fig. 1, is the proboſcis, or that apparatus of a tabanus with which it pierces the ſkin of horſes and oxen, and nouriſhes itſelf with their blood. The ſingular and compound ſtructure, together with the admirable form and exquiſite beauty of this apparatus, diſcovers ſuch a view of the wiſdom, power, and greatneſs of it's infinite compoſer, as muſt ſtrike with admiration every contemplative obſerver, and lead him to reflect on the weakneſs, impotence, and nothingneſs of all human mechaniſm, when compared with the immenſe ſkill and inimitable finiſhing diſplayed in the ſubject before us. The whole of this formidable apparatus is compoſed of ſix parts, (excluſive of the two guards, or feelers, a a,) all of which are incloſed in a fleſhy

caſe, which in the figure is totally removed, as it contained nothing remarkably different from that of other inſects with two wings. The guards or feelers, a a, are of a ſpungy or fleſhy ſubſtance, and are grey, covered with ſhort hairs; they are united to the head by a little joint of the ſame texture, which in this view of the object could not be ſhewn. Theſe guards are a defence to the other parts of the apparatus, as they are laid upon it ſide by ſide whenever the animal ſtings, and by that means preſerve it from external injury. The two lancets, b b and B, evidently open the wound, and are of a delicate and tender ſtructure, formed like the diſſecting knife of the anatomiſt, with a ſharp point and ſlender edge, but gradually increaſing to the back. The two ſhaped inſtruments, c c and C, appear as if intended to enlarge the wound, by irritating the parts round it; to accompliſh which, they are jagged, or toothed; they may alſo ſerve, from their hard and horny texture, to defend the tube e E, which is of a ſofter nature, and tubular, to admit the blood, and convey it to the ſtomach; this delicate part is incloſed in a caſe, d D, which entirely covers it. Theſe parts are drawn ſeparately at B, C, D, E. De Geer obſerves, that it is only the females that ſuck the blood of animals; and Reaumur declares, that having made one diſgorge itſelf, the blood it threw up appeared to him to be more than the whole body of the inſect could have contained.

The exuvia, or caſt ſkin of inſects, being exceedingly tranſparent, are well adapted for obſervation, as they exhibit the outward appearance of the little animal; among theſe we may reckon thoſe of ſpiders and cimeces, but particularly the ſorficula, or earwig, which is an elegant exuvia. The ſtings of inſects vary not only in their form, but alſo in their apparatus; moſt of them require diſſection, as the ſtings (for they have generally two) are incloſed in a hard ſheath, or caſe, to which is added a pair of feelers. The ſtings of bees, waſps, &c. are barbed, while that of the chryſis is ſerrated, or notched like a ſaw.

The head of inſects is furniſhed with an inſtrument, or proboſcis, various as the inſects themſelves, but all deſerving the utmoſt attention, being admirably adapted to their different uſes and purpoſes. Among the moſt remarkable are the bed bug, flea, gnats, empis, conops, &c. to which we may add the ſingular one of the tabanus, which we have juſt now deſcribed. We have alſo ſo fully deſcribed the bee's apparatus, page 362, that it is unneceſſary to enlarge on it here.

The antennæ of moths, butterflies, and moſt other inſects, diſplay as great beauty in their formation as they are endleſs in their variety; the diſtinguiſhing characters of many of them have been deſcribed, page 175; and that of the lepas antifera in particular, page 359.

The eyes of inſects are ſingularly conſtructed, but this ſtructure is not diſcoverable without the aſſiſtance of the microſcope; the eyes of the libellula are hexagonal, vide Plate XVI. Fig. 3; while thoſe of lobſters are ſquare, as may be ſeen Plate XVI. Fig. 5.

Hair of animals, as the mouſe, goat, large bee, and many ſpecies of caterpillar, particularly the tufts on the head and tail of the larva of the phalæna antiqua, offer many beauties to the curious obſerver. The briſtles of a hog, cut tranſverſely, appear tubular, and the root of hair is evidently bulbous.

The muſcular fibres, and every anatomical preparation that can be brought under the microſcope, are pleaſing objects; the reader will meet with many curious and intereſting obſervations on the hairs, the muſcles, nerves, and other parts of the human body, in Fontana's Treatiſe on the Venom of Vipers, printed for Murray.

The legs of all inſects appear very much diverſified, and their mechaniſm truly aſtoniſhing, according with their different occupations, as particularized page 179.

Scales of fiſh, as ſoals, roach, dace, ſalmon, eels, &c. as alſo the ſcales of ſnakes, lizards, &c. &c. A ſpecimen of ſcales is given, Plates X. and XIX. The ſcales form a light, but at the ſame time a ſolid and ſmooth covering to the fiſh, they hinder the fluid from penetrating the body, for which purpoſe they are laid in a kind of natural oil; they ſerve alſo as a protection, and break the force of any accidental blow, which may be the reaſon why river fiſh have larger and ſtronger ſcales than ſea fiſh, being more liable to accidents.

Feathers, and parts of feathers, are not to be paſſed by or unnoticed; but it is impoſſible to point out any of theſe in preference to others, as each has it's peculiar beauties; the plumula of theſe have generally in the microſcope the appearance of a large feather; the pith contained in the quill, if cut tranſverſely, and examined, exhibits an admirable reticular texture. Many other parts of birds will afford a great variety of curious objects, particularly the egg: Mr. Martin ſays, that the internal ſpungy ſubſtance of bones may be better obſerved in thoſe of birds than of any other animal; even the feathers or ſcales of a moth's wing amply repay the obſerver; theſe alſo vary in their texture and figure; but the largeſt, and moſt commonly applied, are from the body of the ſphinx ſtellatarum, or humming-bird moth; a ſpecimen is given, Plate XVI. Fig. E F H I.

Tranſverſe ſections of all kinds of wood, eſpecially thoſe of a pithy or ſoft nature; their beauty will be ſeen by the figures in Plates XXVII. XXVIII. XXIX.

The flowers of moſt graſſes, with all the varieties of moſſes; the farina of flowers; mouldineſs, which evidently appears to vegetate; all the kinds of ſpunge, ſea weeds, particularly the confervæ, which is jointed like a cane. The extenſive family of corallines preſent an elegant appearance; the moſt beautiful are the ſea hair, ſea fir, ſickle, fox tail, &c. deſcribed by Ellis.

Diſſected leaves, which ſhew the fibres and nerves; the human inteſtine, injected with wax, is a fine object, as are many other anatomical preparations. The ſeed of the ſilver-rind birch appears like an inſect; ſeed of the quaking graſs is alſo much admired, as is the leaf which covers the ſeed of ſorrel. Among artificial productions, the edge of a razor, and point of a fine needle, as alſo fine cambrick, evidently diſcover the inferiority of the workman; particles from the colliſion of flint and ſteel, wire melted by the electric exploſion, &c. &c. &c.

The preceding objects being moſt of them eaſy to be procured by thoſe who have leiſure, and are frequently in the country, an endleſs variety may be added to them; but thoſe lovers of the icroſcope, who may have neither leiſure nor opportunity to ſearch for themſelves, may be ſupplied with all, or moſt of them, or indeed with objects to almoſt any extent, by applying to me, No. 60, Fleet-Street, London.

Beſides the above, there are an immenſity of objects which can only be examined alive, or when found, ſuch as polypes, minute aquatic inſects; animalcula, of various infuſions, as eels in paſte, vinegar, &c. The eyes and teeth of ſnails, the circulation of the blood in the tail of fiſhes, &c. The ſhooting of ſalts, &c.

The following extract from a truly philoſophical writer, will, I hope, prove acceptable to the reader, as well as form a proper concluſion to this work.

"How admirable are the works of God! how excellent the operation of his hands!

I conſidered plants, and animals; four-footed beaſts, and creeping things.

In all was manifeſted infinite wiſdom, and an excellent workmanſhip, that I could not comprehend.

Yet ſo much was made known unto me, as declared the power and goodneſs of God, and the continued agency of the great Creator, and Lord of all things.

I beheld the caterpillar iſſuing from it's egg, on the very plant needful for it's ſupport:

For there the parent fly had placed it, that it might have whereon to feed.

It enjoys the repaſt, it weaveth it's web, and, preparing for it's end, buildeth itſelf a rich tomb.

It reſteth from it's labours, and ſleepeth the ſleep of death.

At the appointed time it is raiſed again, and the great Creator of all things giveth it a new life.

It leaveth it's aſhes in the tomb, and aſcends, with a more beauteous form, into the regions of the air.

How glorious are it's wings! and it's limbs how delicate!

It is covered with a rich plumage; and furniſhed with myriads of eyes, to behold all around.

With it's trunk it ſurpaſſeth the art of the chymiſt, and extracteth from flowers the moſt delicious ſweets.

It forſakes the leaf whereon it was firſt nouriſhed, rejoicing in the bounty of it's Maker.

But, at his command, it is mindful of it's offspring, and provides for the ſafety and ſuſtenance thereof.

With anxious care it ſeeketh out the plant which God hath given for it's infant worms.

Though it feedeth not thereon, neither careth for the verdant leaves, yet is it led with unerring ſearch, and never faileth in it's choice.

It curiouſly ſpreadeth forth it's eggs; and without thought, fulfilleth it's appointed taſk.

The bee juſt raiſed to life, without a teacher ſkilfully forms her cell.

The ſage's art is known to her: ſhe has diſcovered the moſt capacious form, and the beſt diviſion of ſpace.

Without ſcale or compaſs ſhe nicely meaſureth her work, and with great care ſtrengtheneth it's foundations.

She layeth her foundations in the upper part; ſhe buildeth downwards, even unto the ground; and exquiſitely finiſheth her work, ſurpaſſing the art of man.

Behold! we perceive as yet but a ſmall portion of his works; we ſee the operations of his hands as through a glaſs darkly; yet how excellent do they appear!"*

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* Hymns to the Supreme Being, in Imitation of the Eaſtern Songs.

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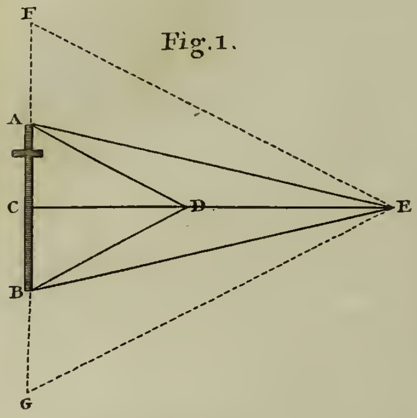

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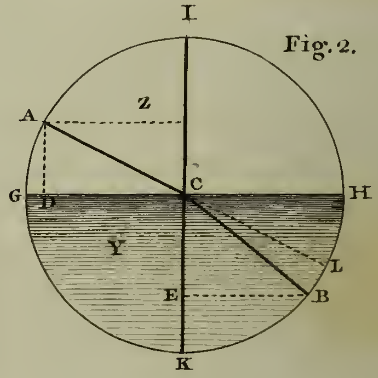

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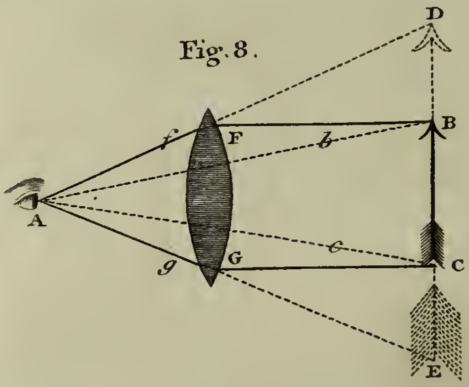

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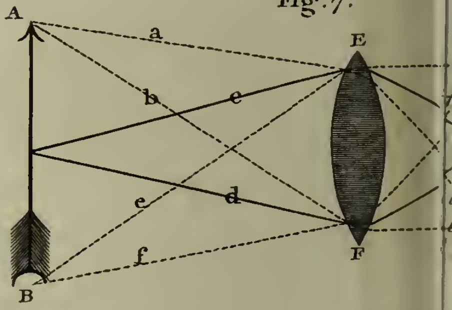

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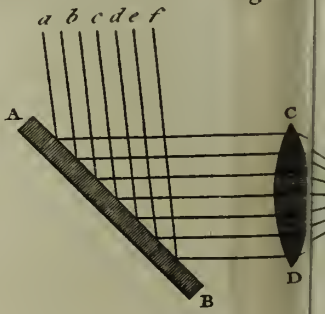

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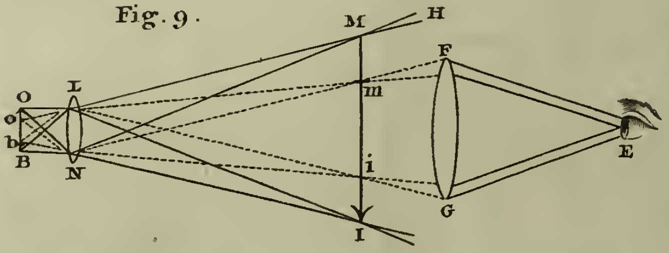

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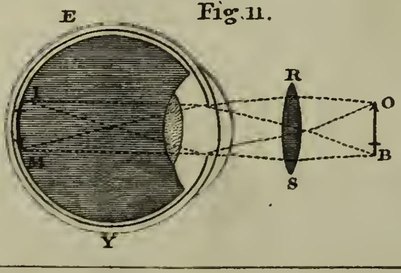

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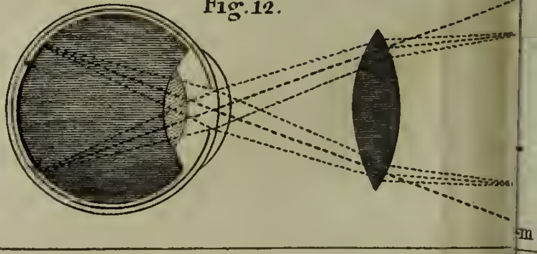

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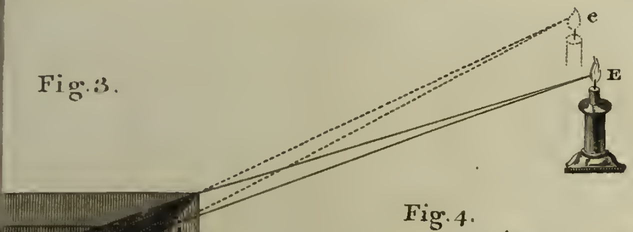

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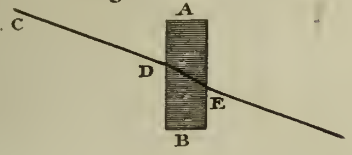

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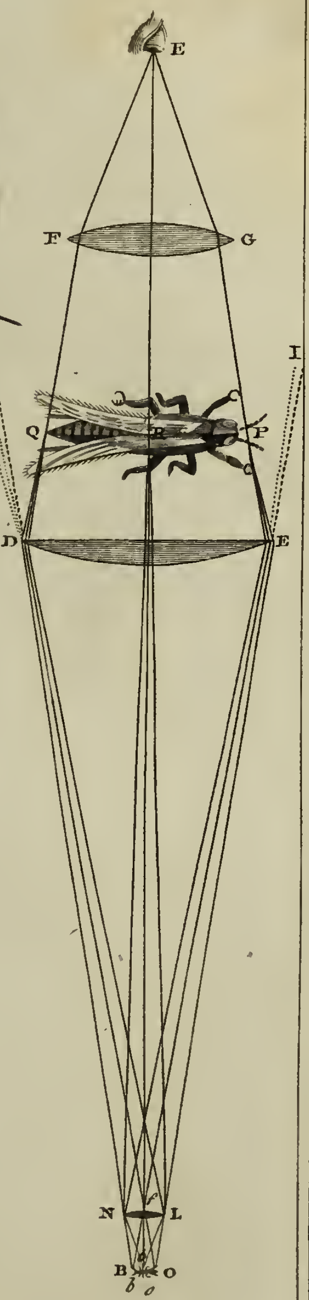

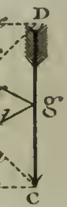

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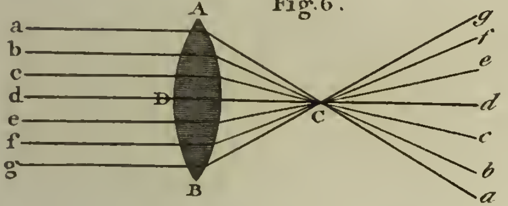

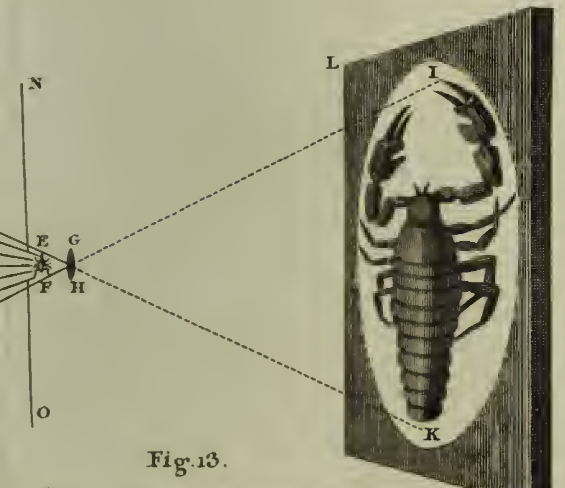

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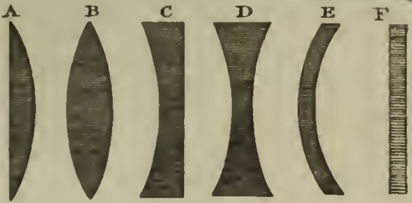

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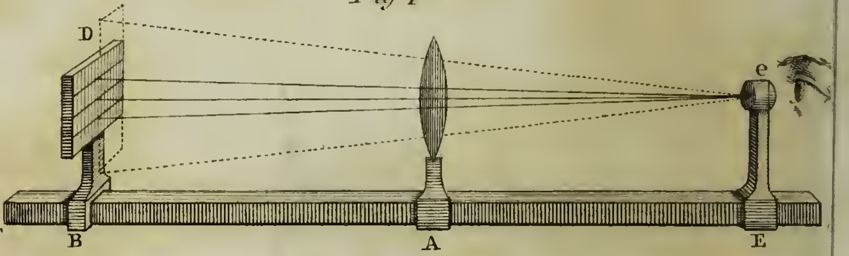

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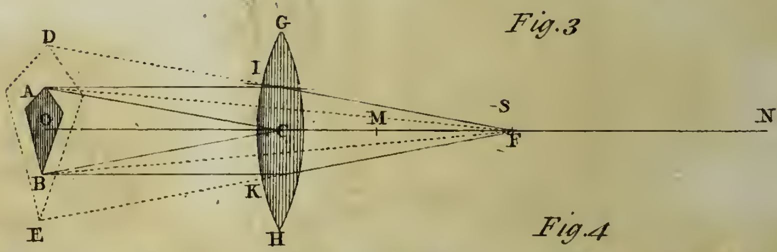

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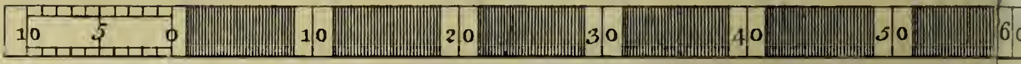

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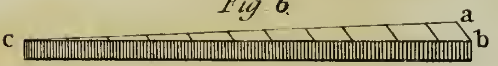

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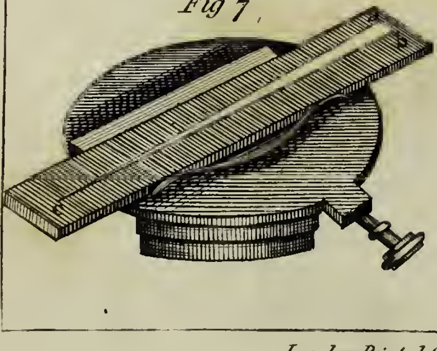

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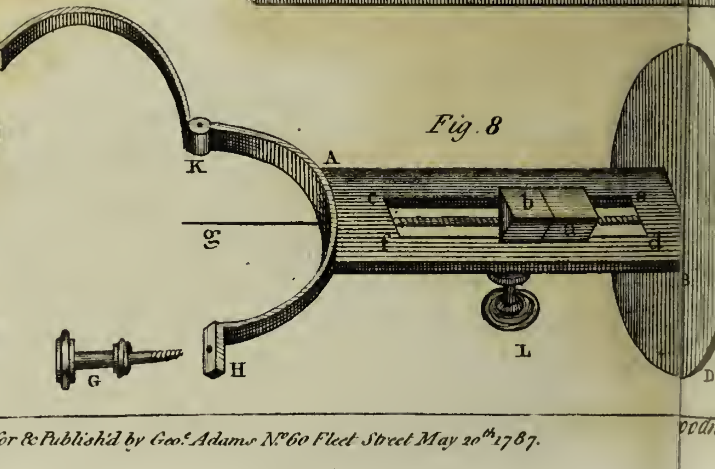

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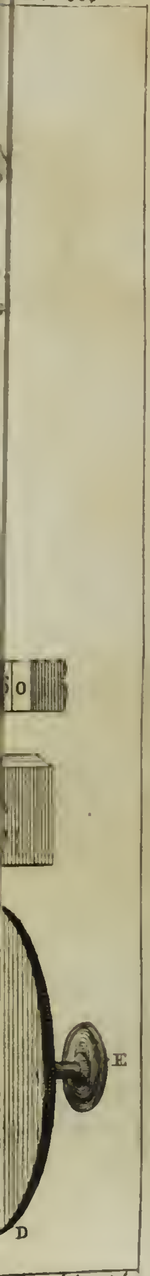

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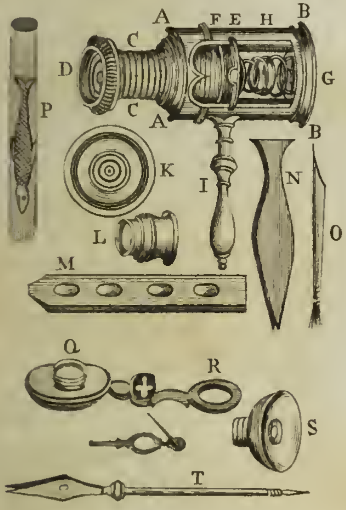

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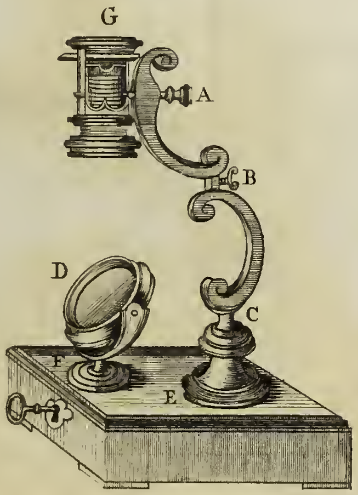

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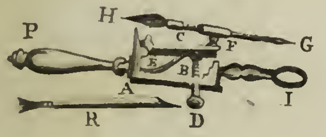

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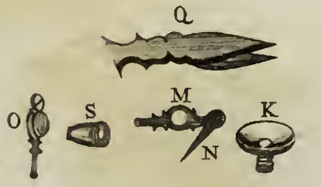

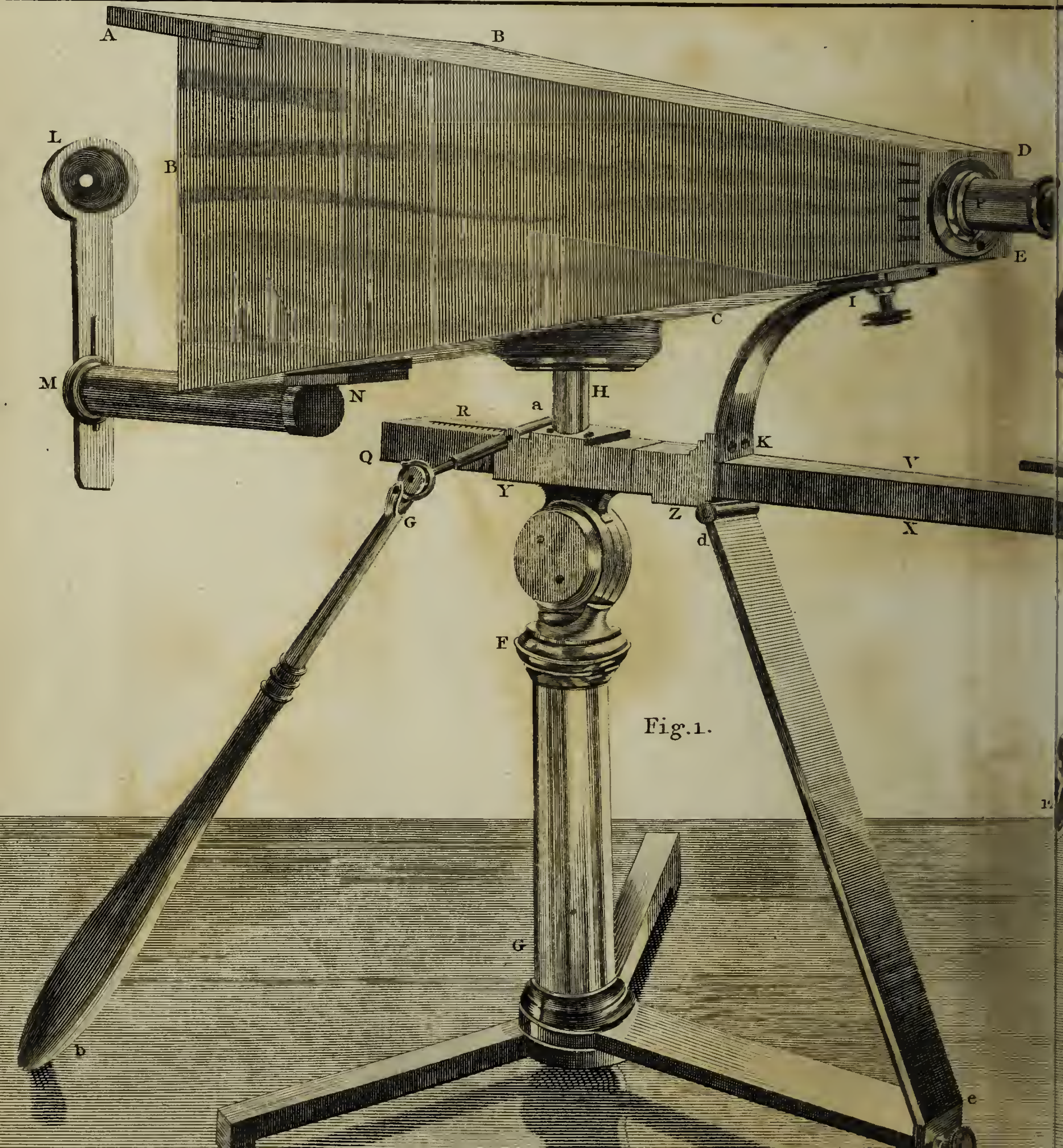

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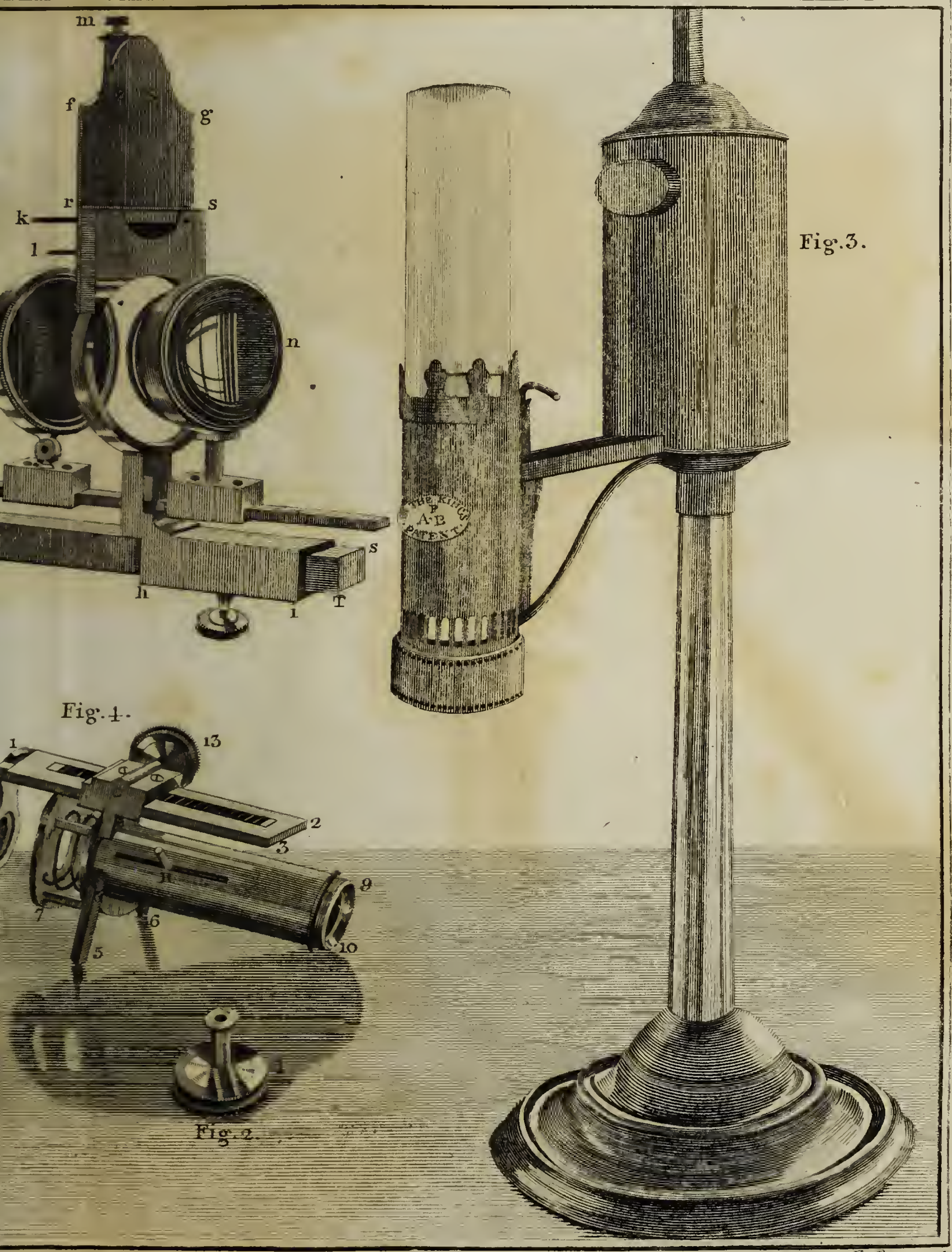

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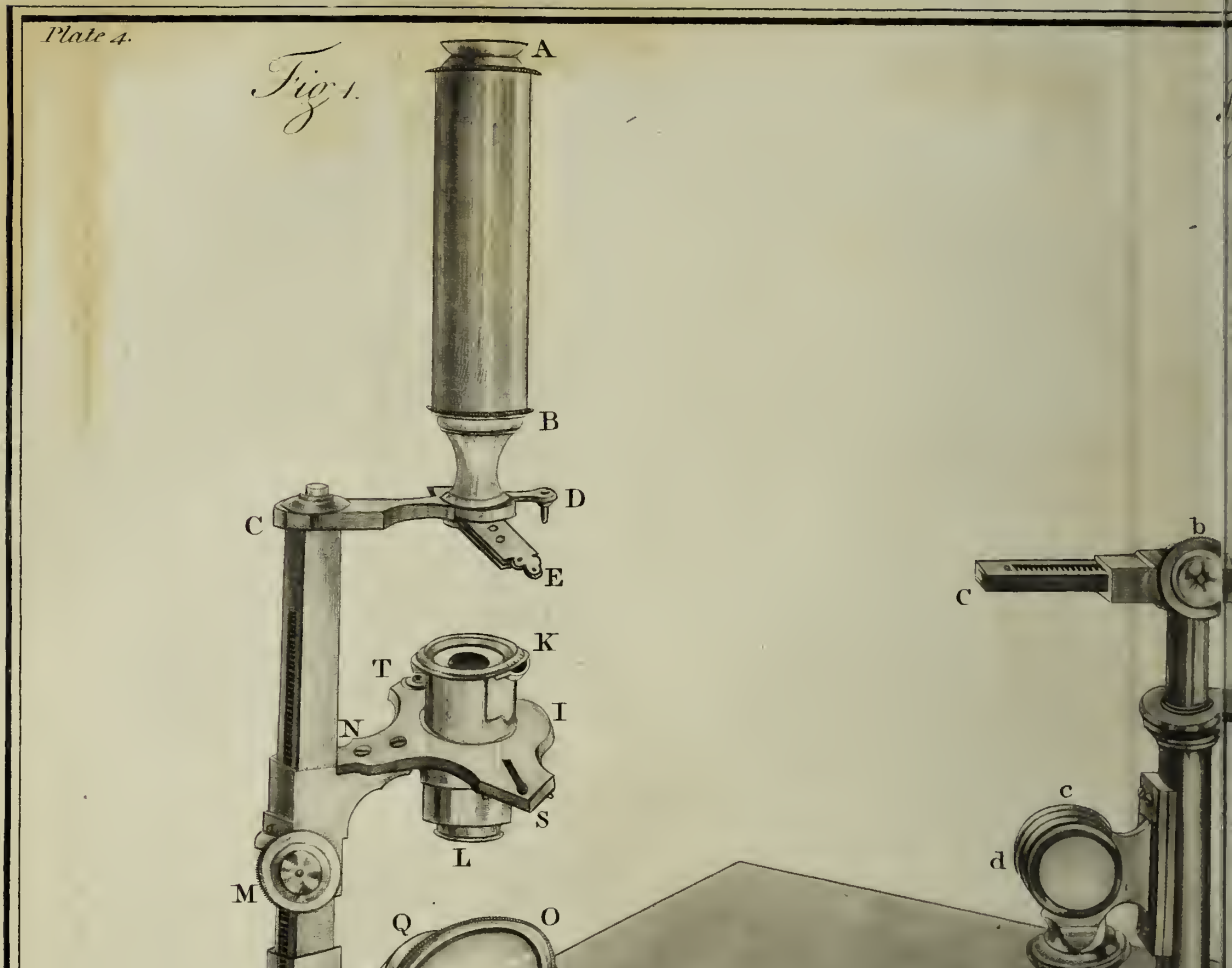

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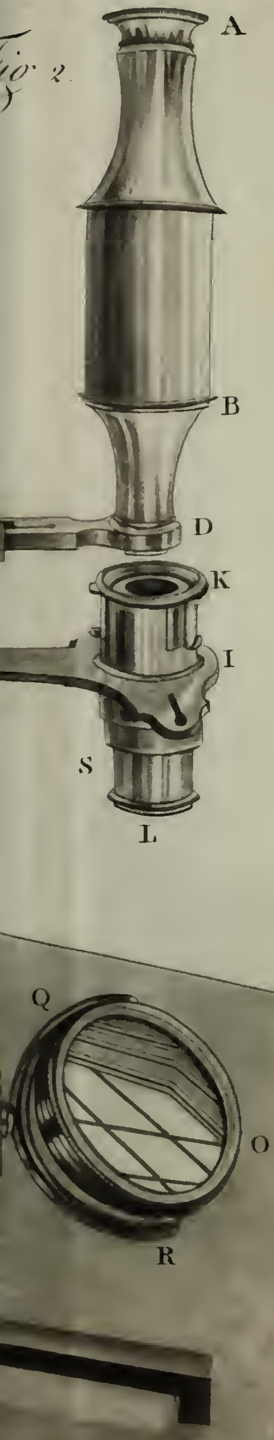

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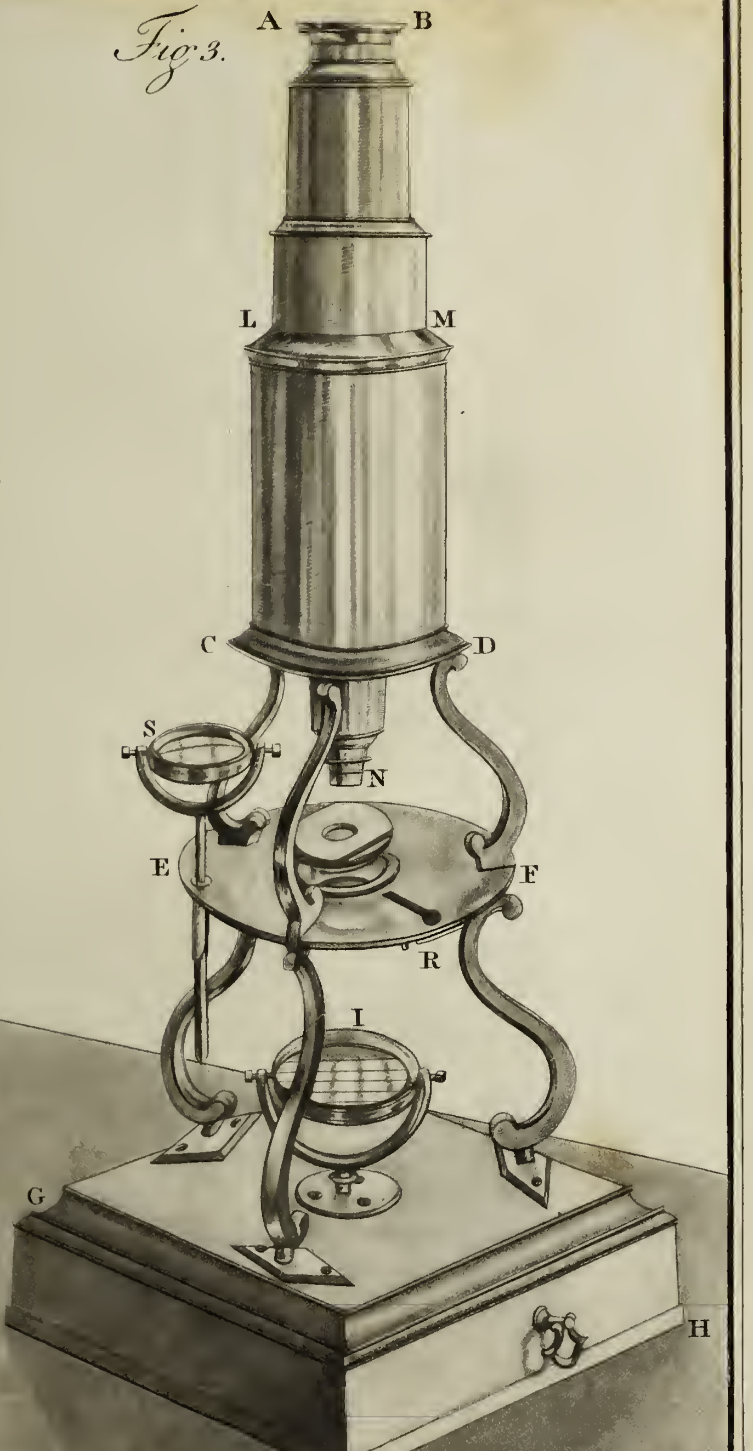

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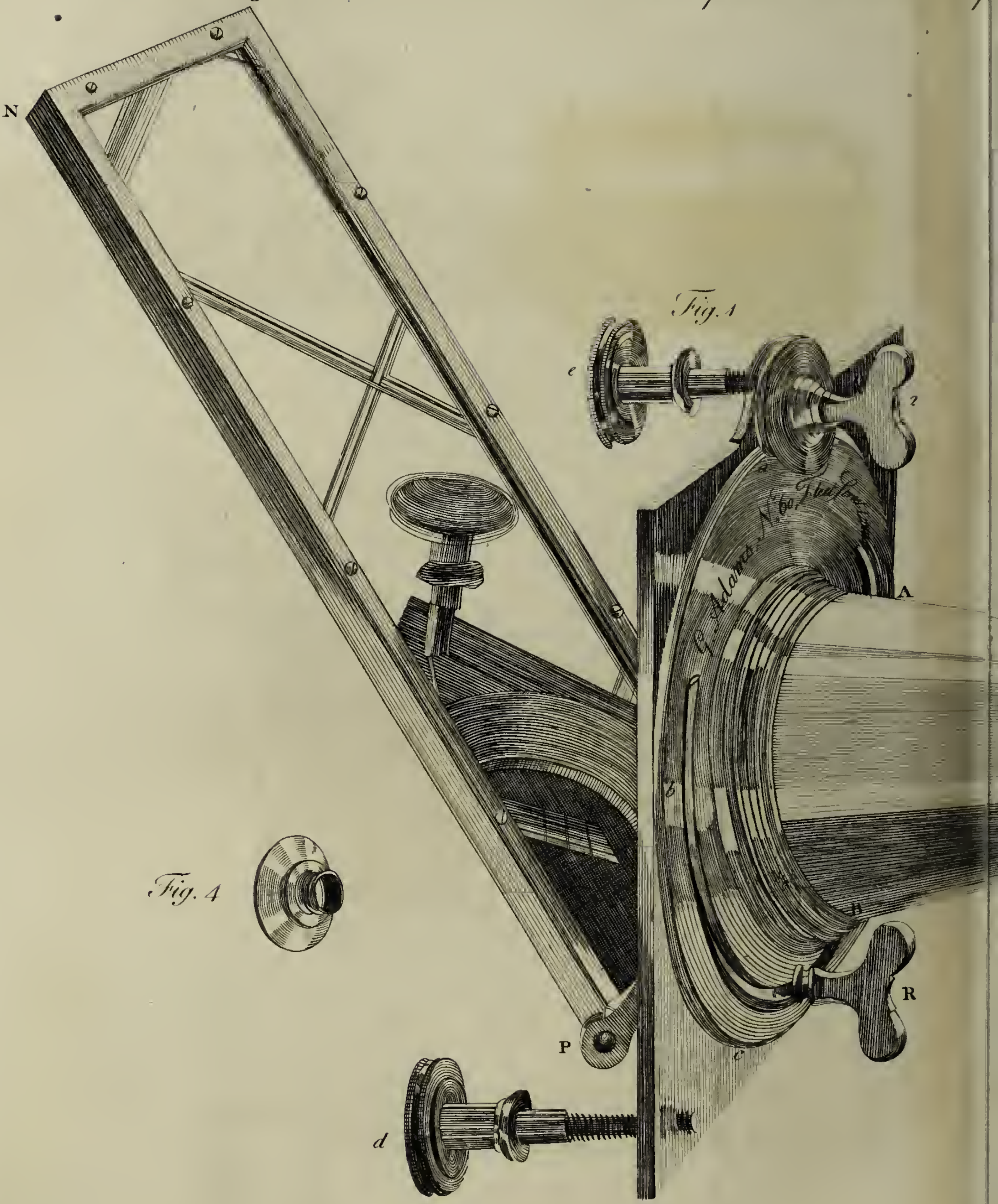

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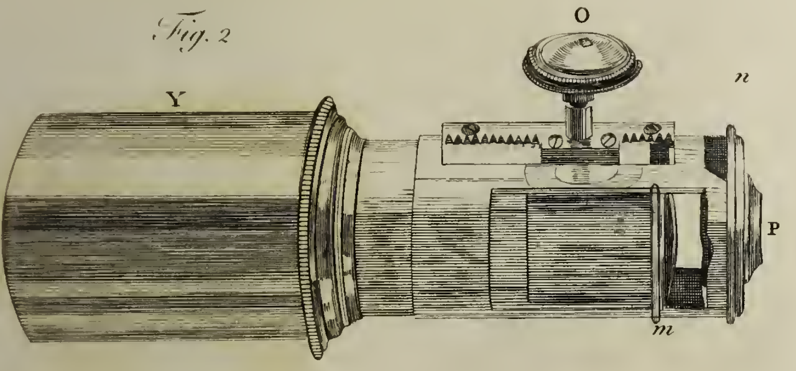

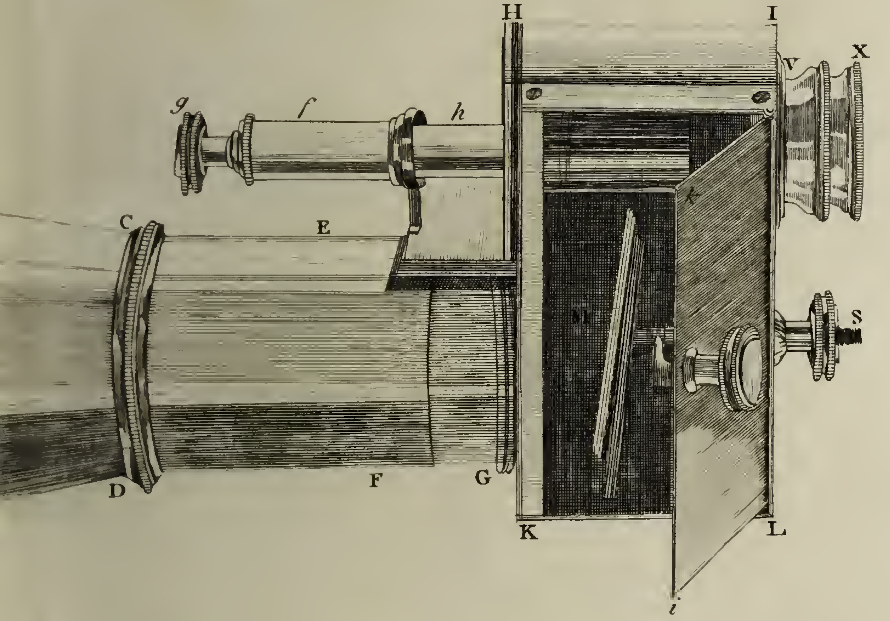

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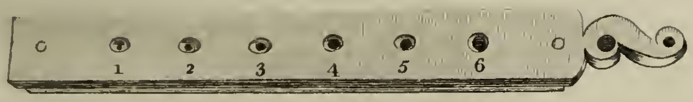

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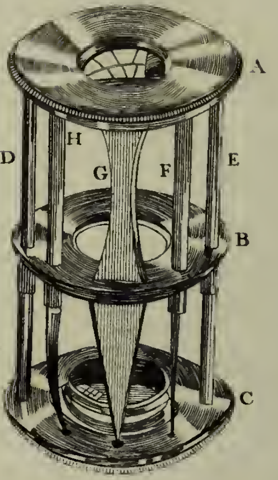

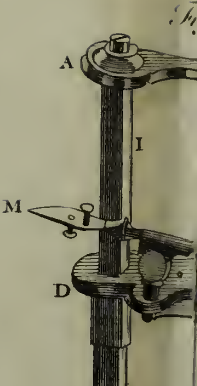

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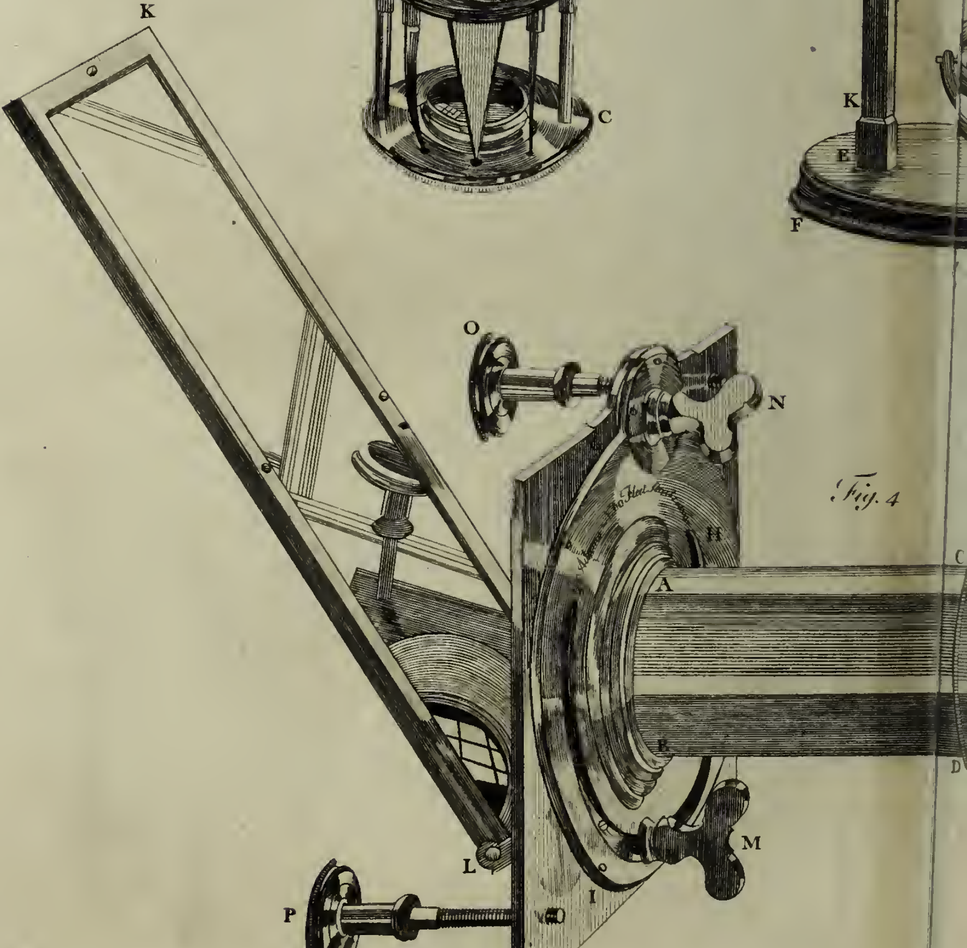

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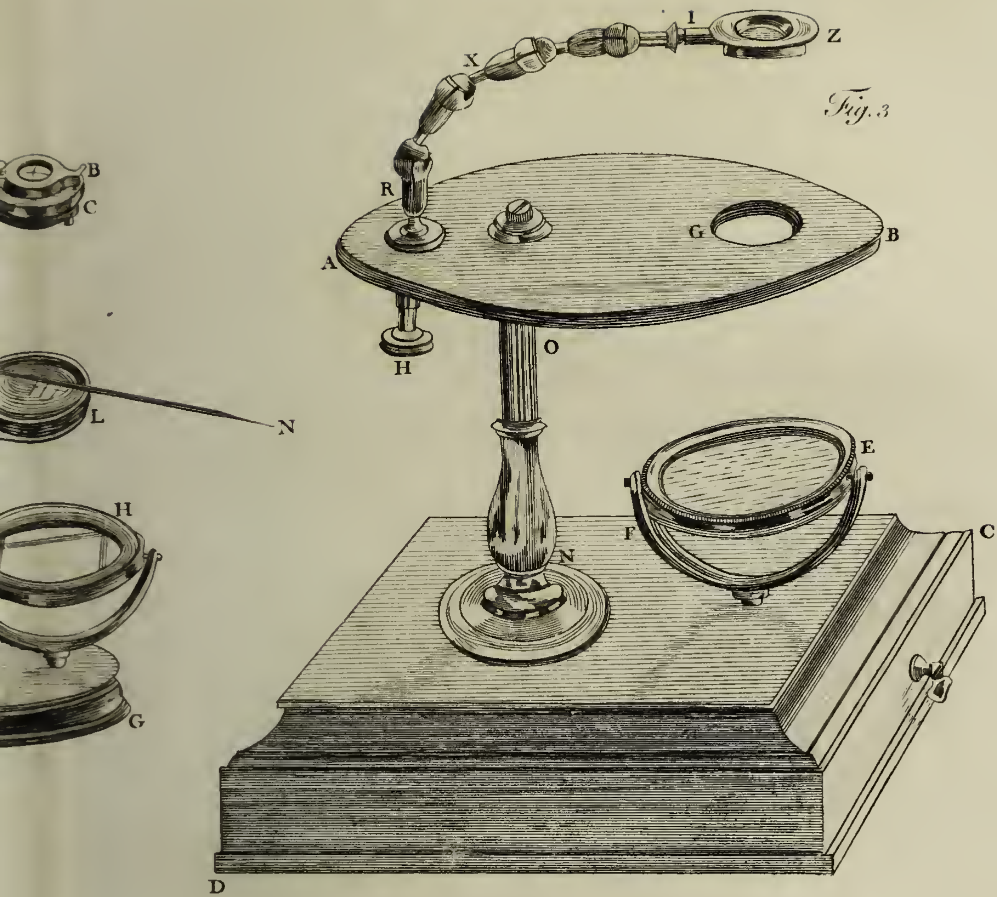

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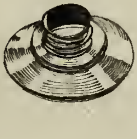

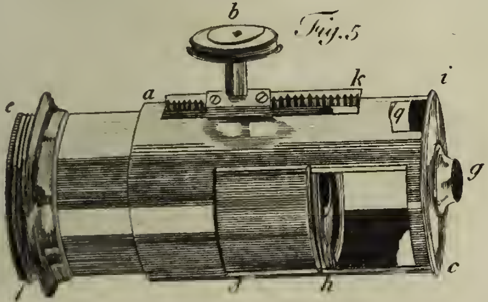

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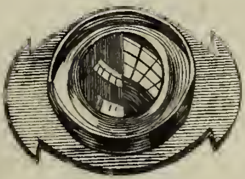

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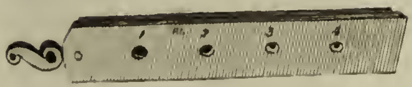

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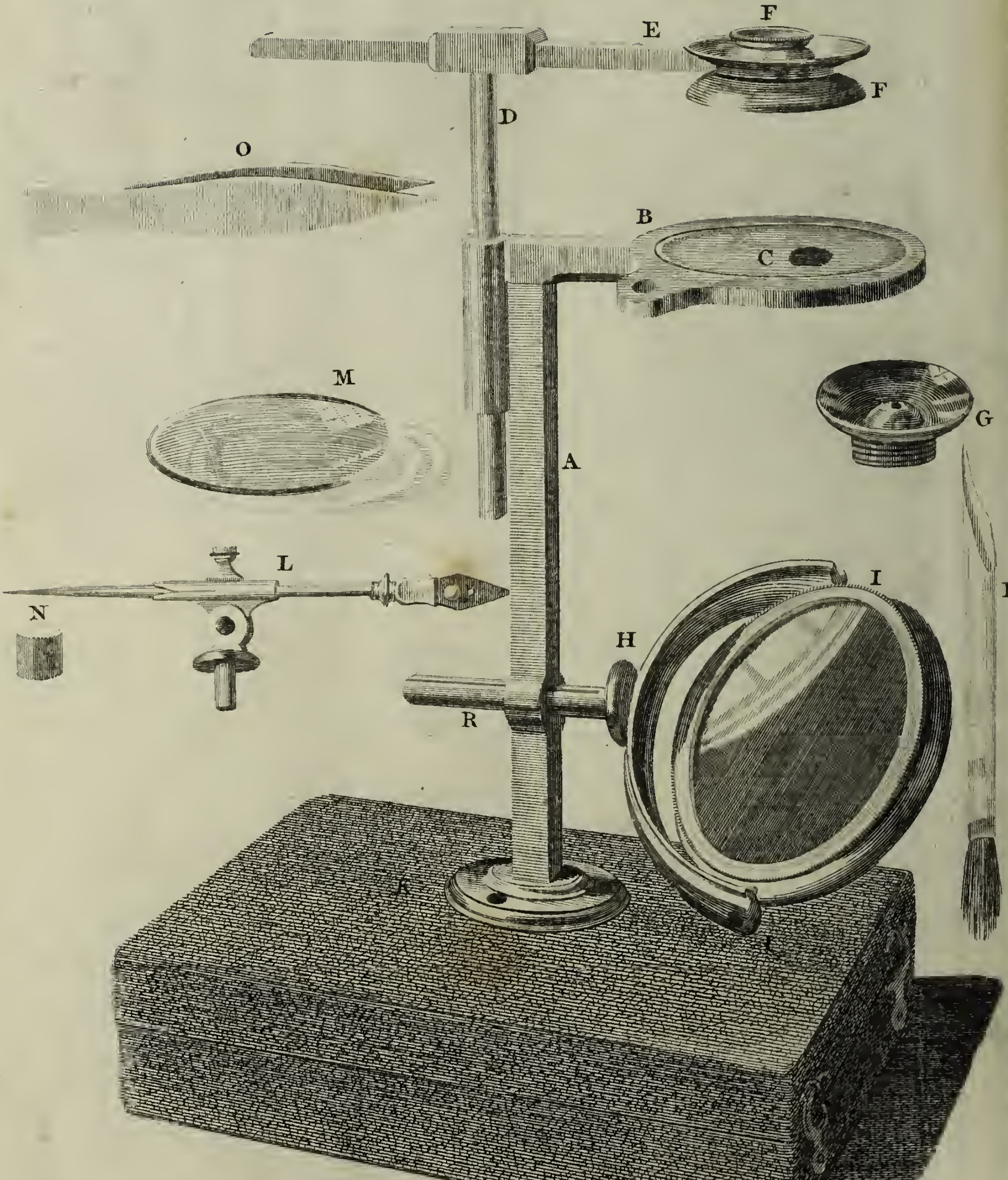

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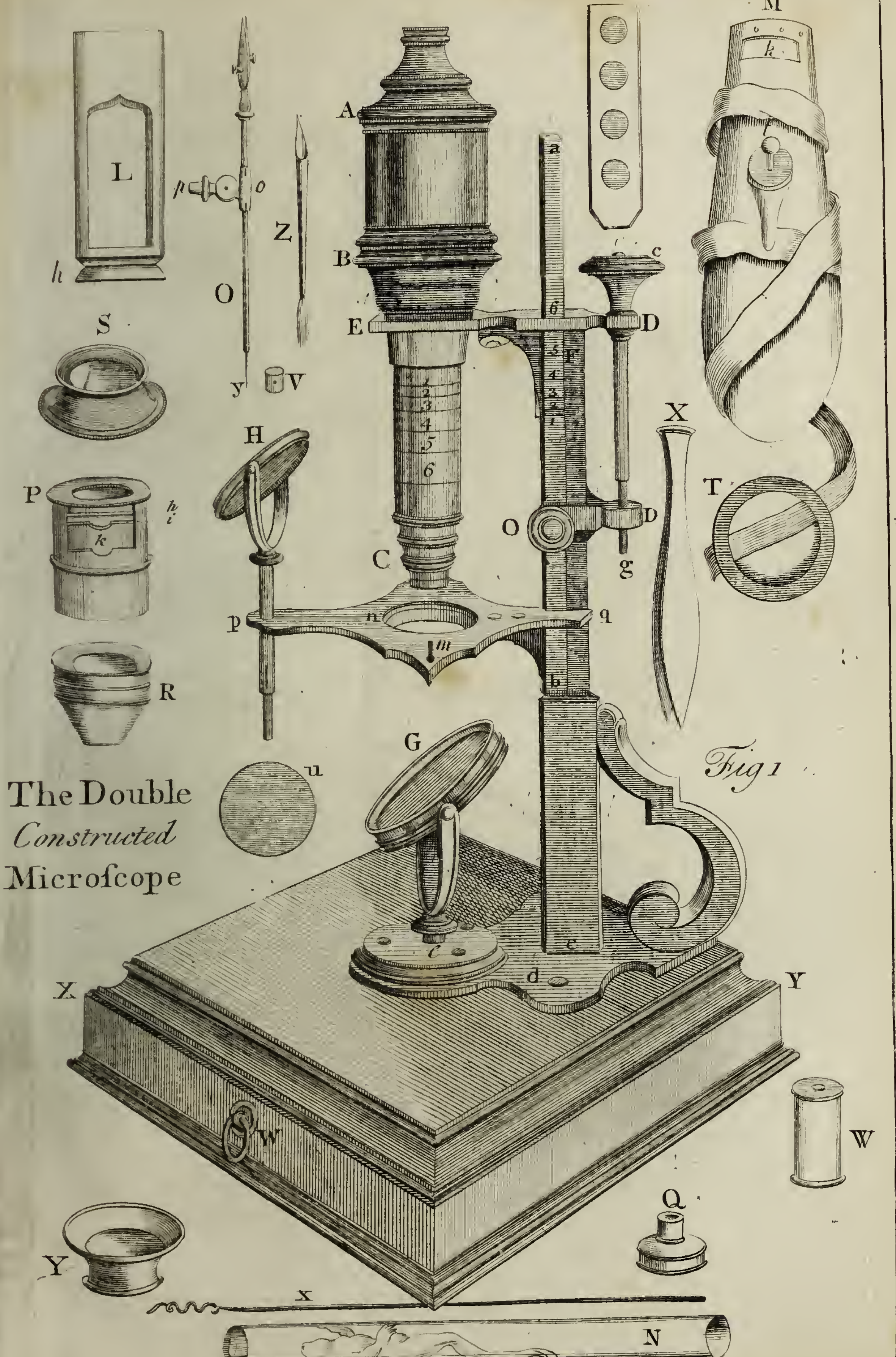

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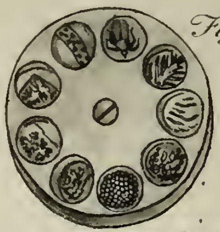
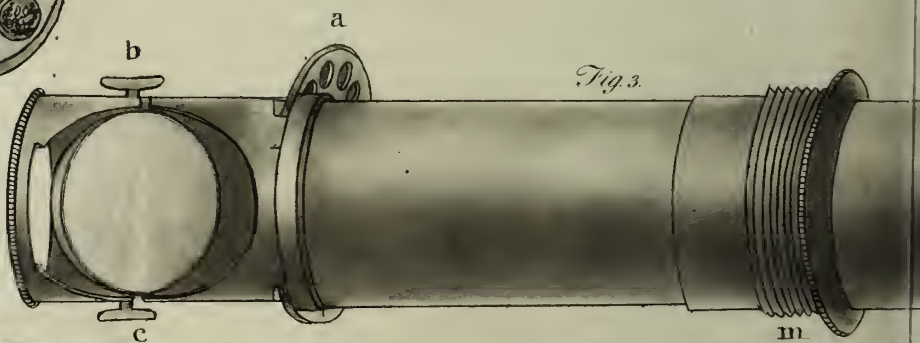


Fig. 2.



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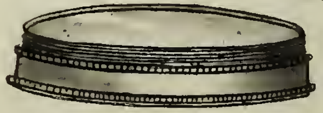

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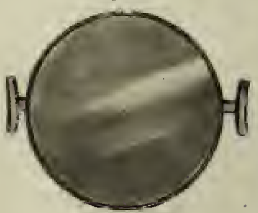

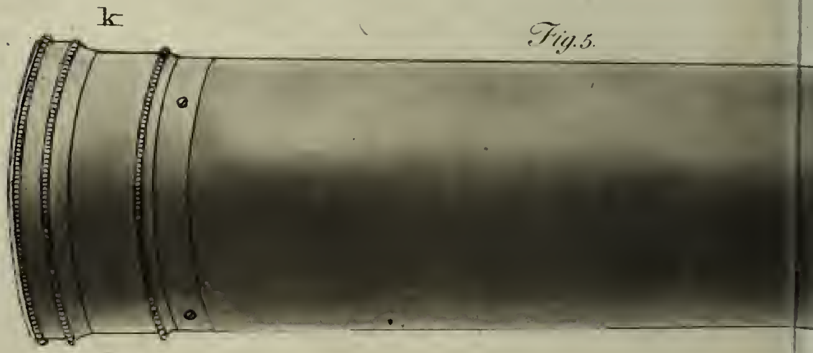

Fig. 5.

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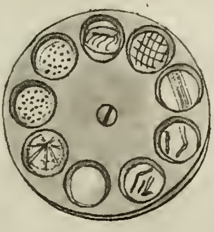
Plate 8.



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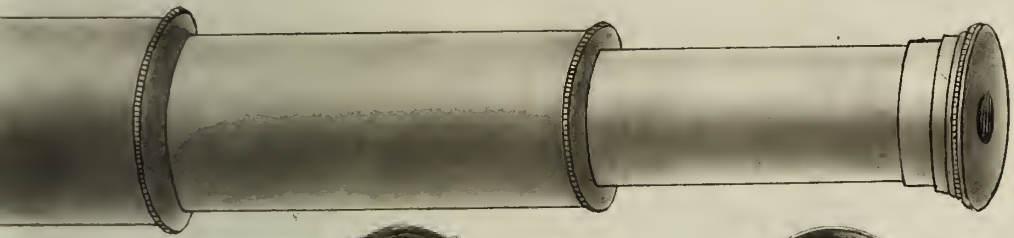

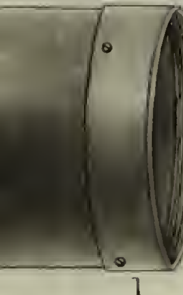

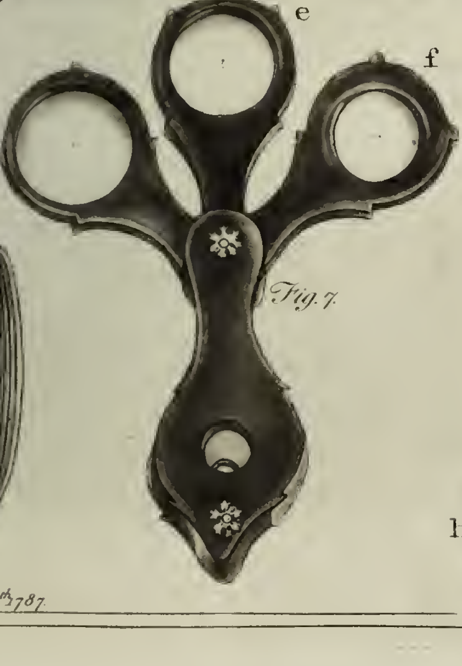

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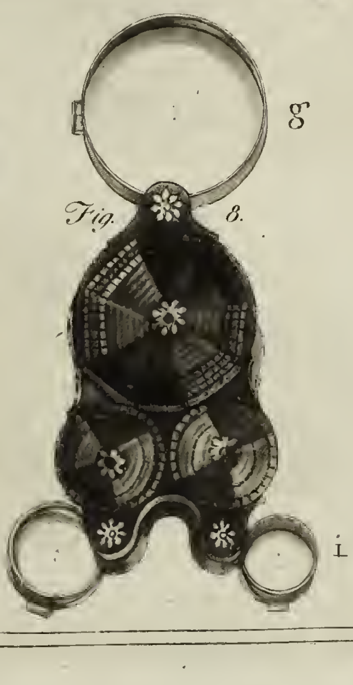

Fig. 8.

60 Fleet Street May 20th 1787.

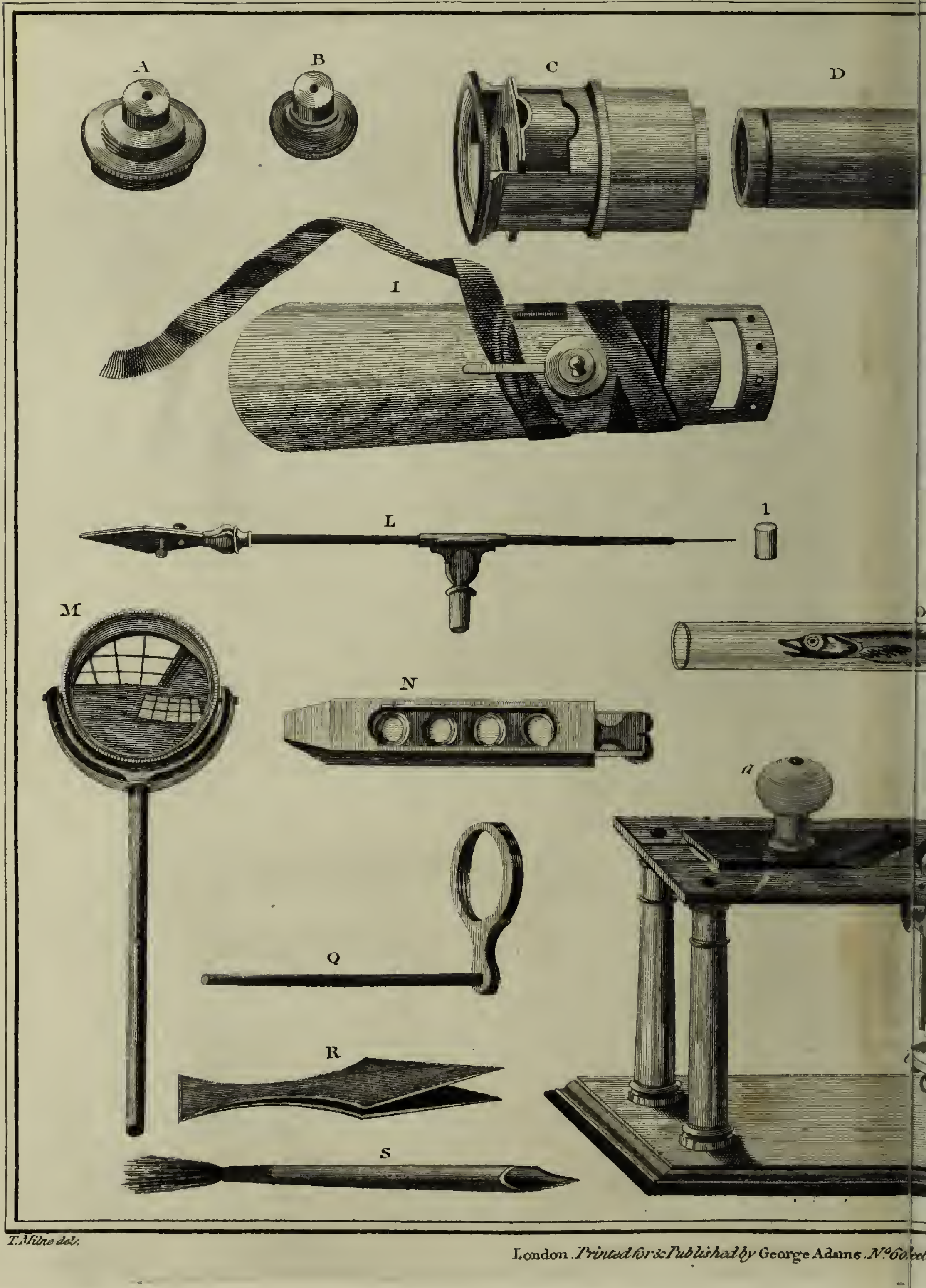

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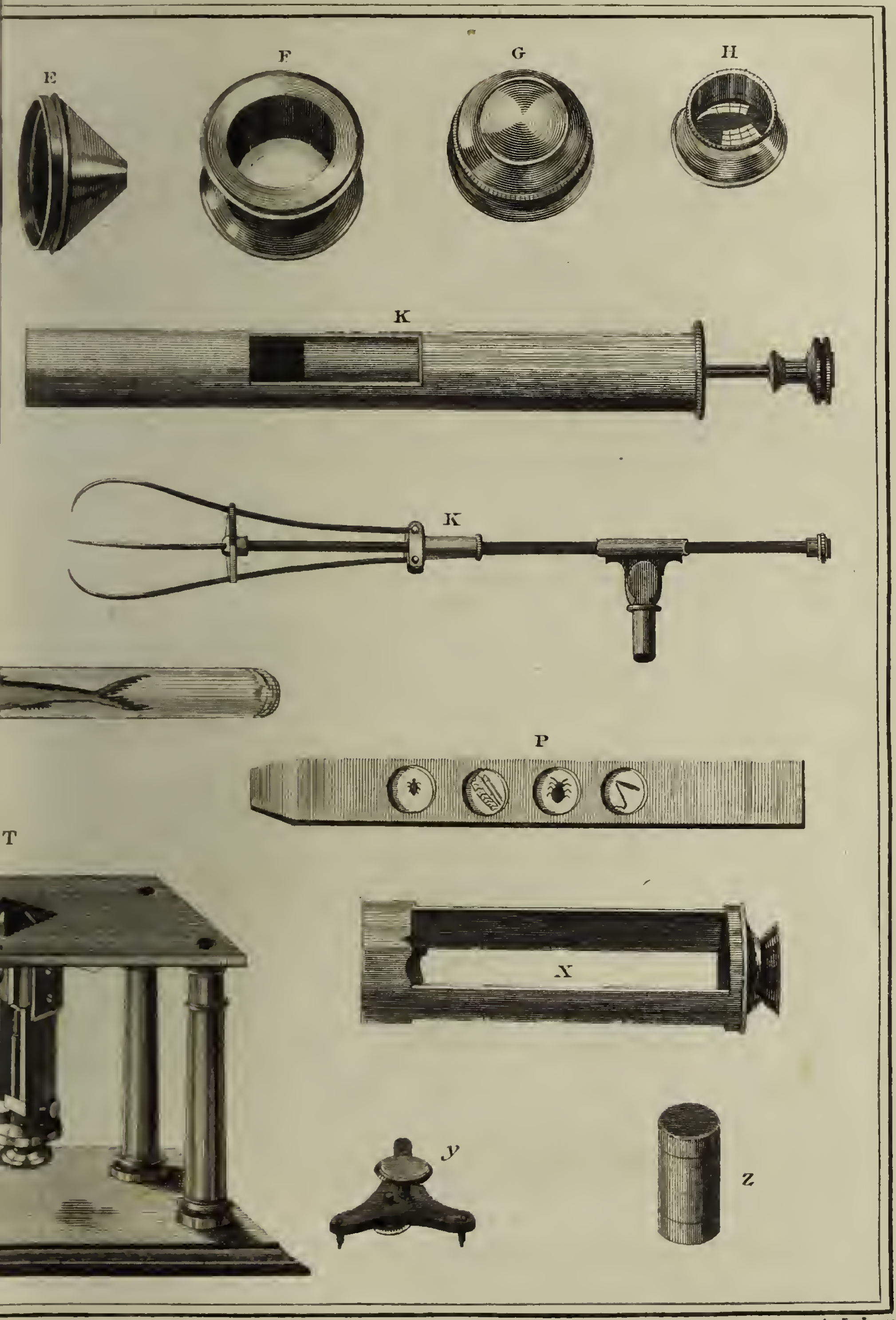
PLATE IX.



Jn. Lodge sc.

t Street. as the Act directs. May 20.1787.

Plate 10.

Fig. 1.

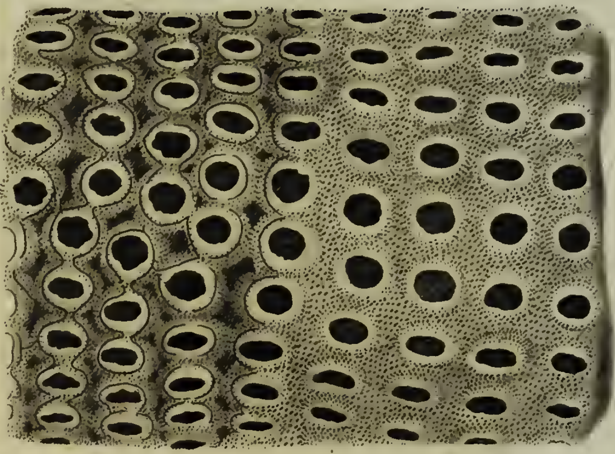
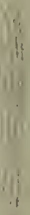


Fig. 2.

Fig. 3



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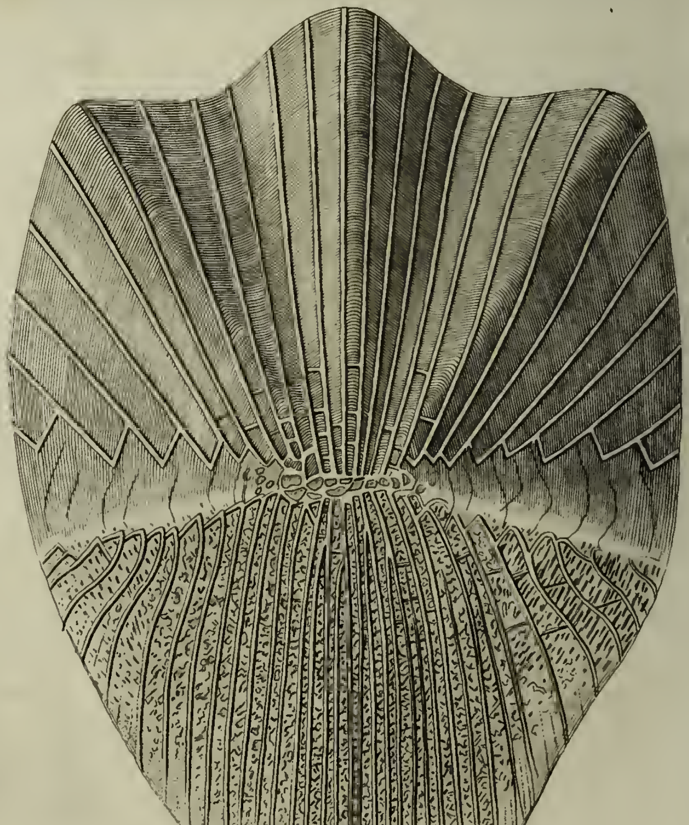

Fig. 8.

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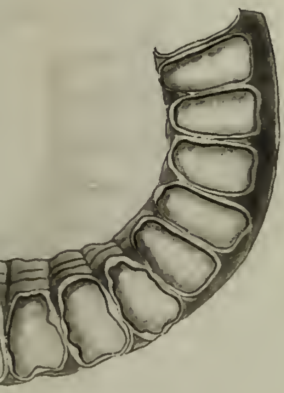
Fig. 4.



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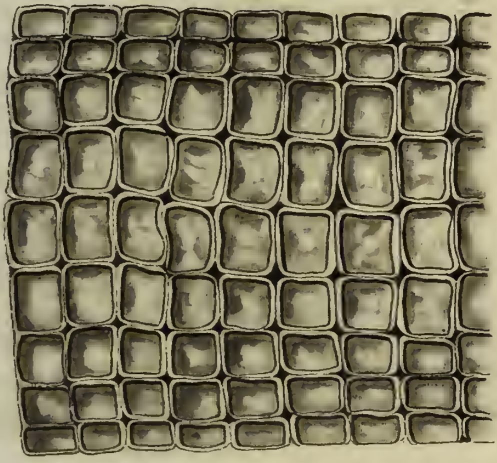

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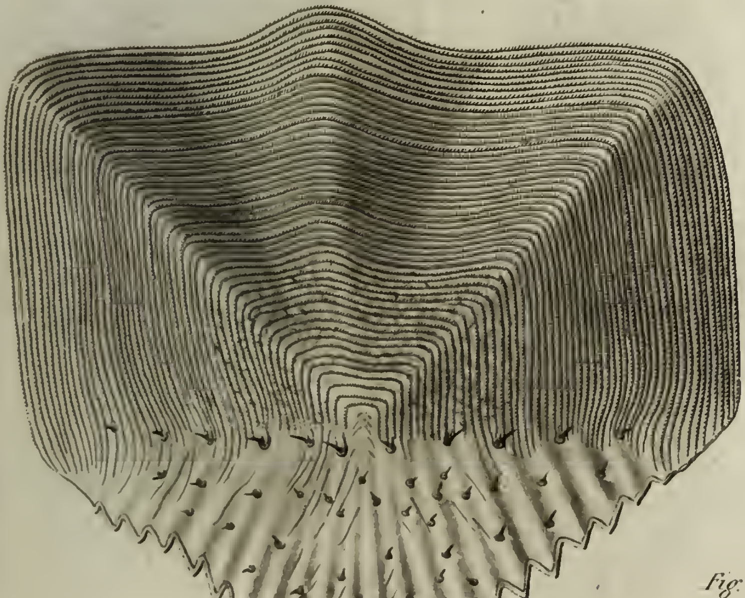

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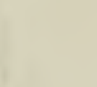

N°60 Fleet Street May 20th 1787

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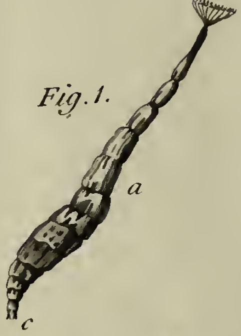

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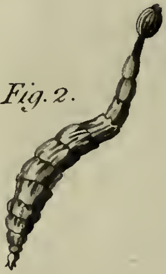

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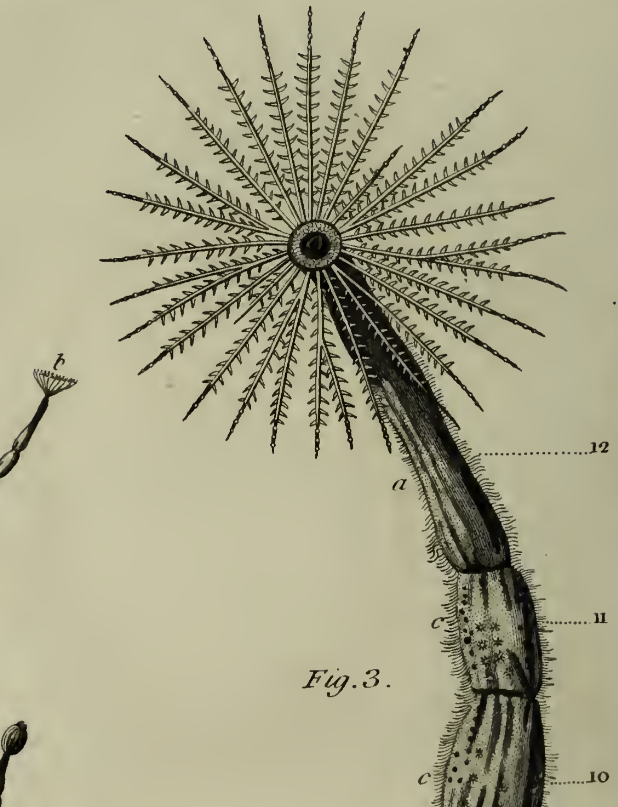

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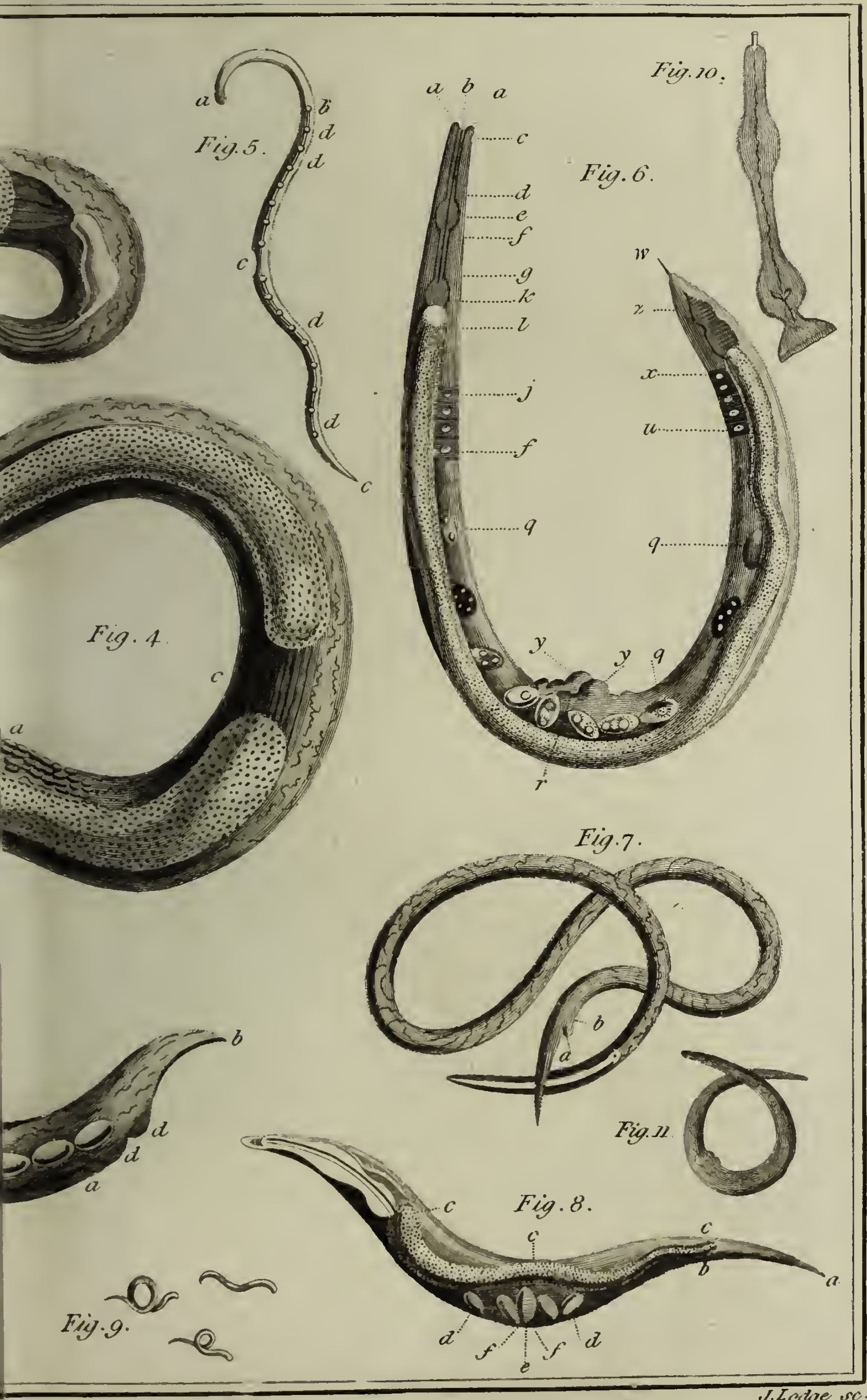
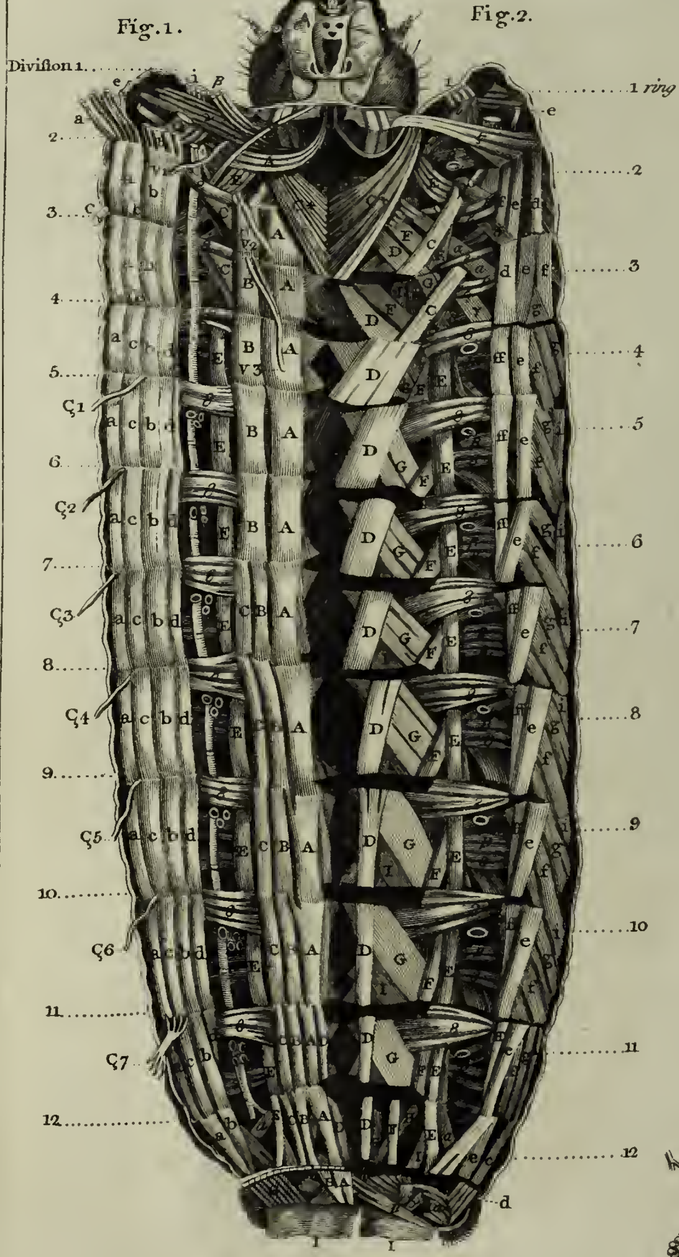


Street as the act directs May 20.1787.

J. Lodge sc.

Fig.1. Fig.2.



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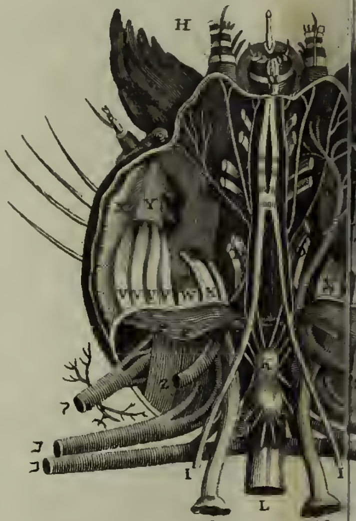

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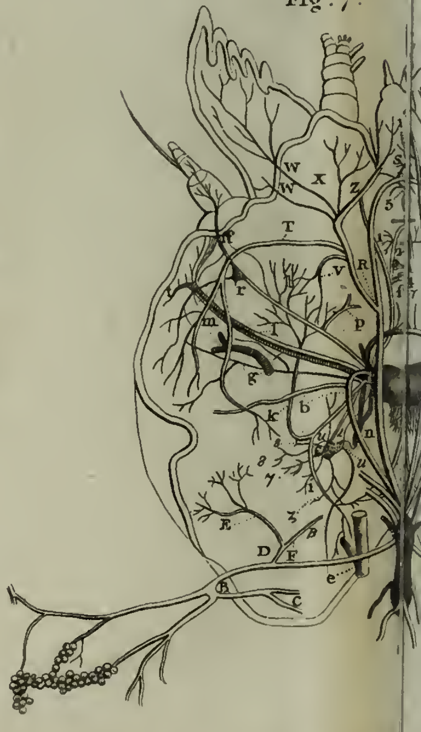

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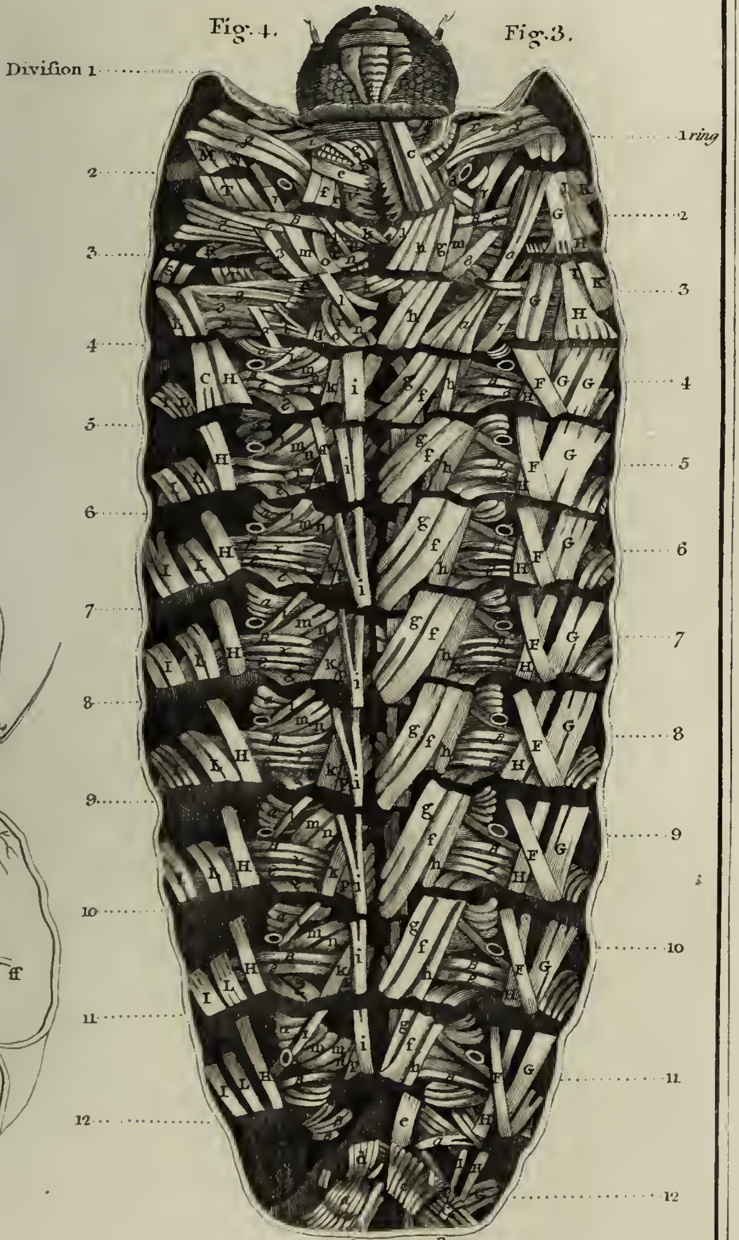
5.

Fig. 4.

Fig. 3.



treet as the act directs. May 20 1787.

Jn.o Lodge sculp.

Fig. 3.

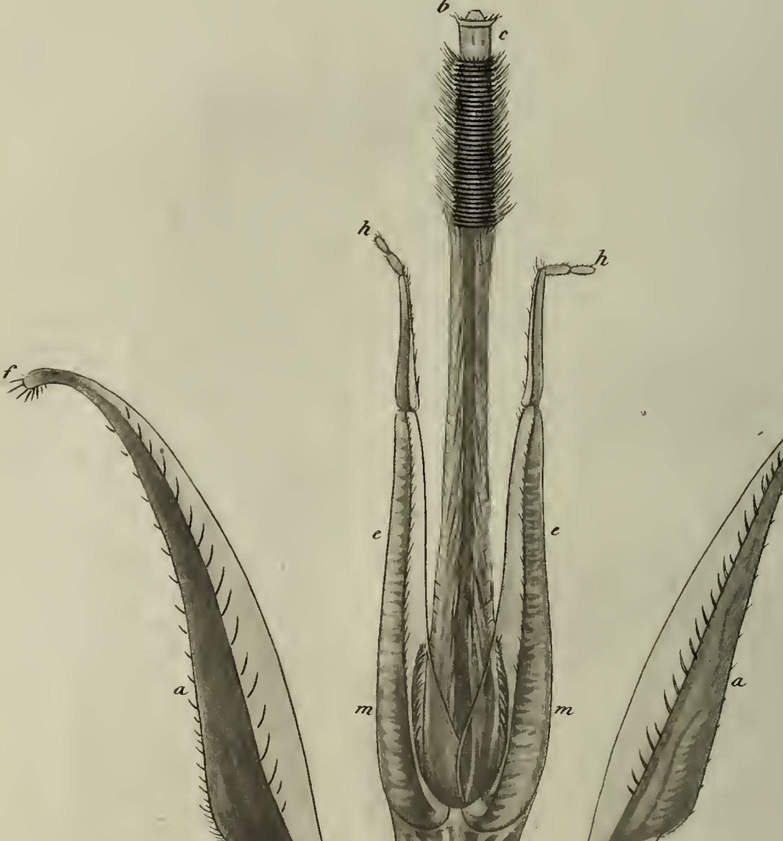
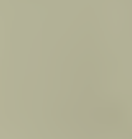


Fig. 4.

Fig. 2.



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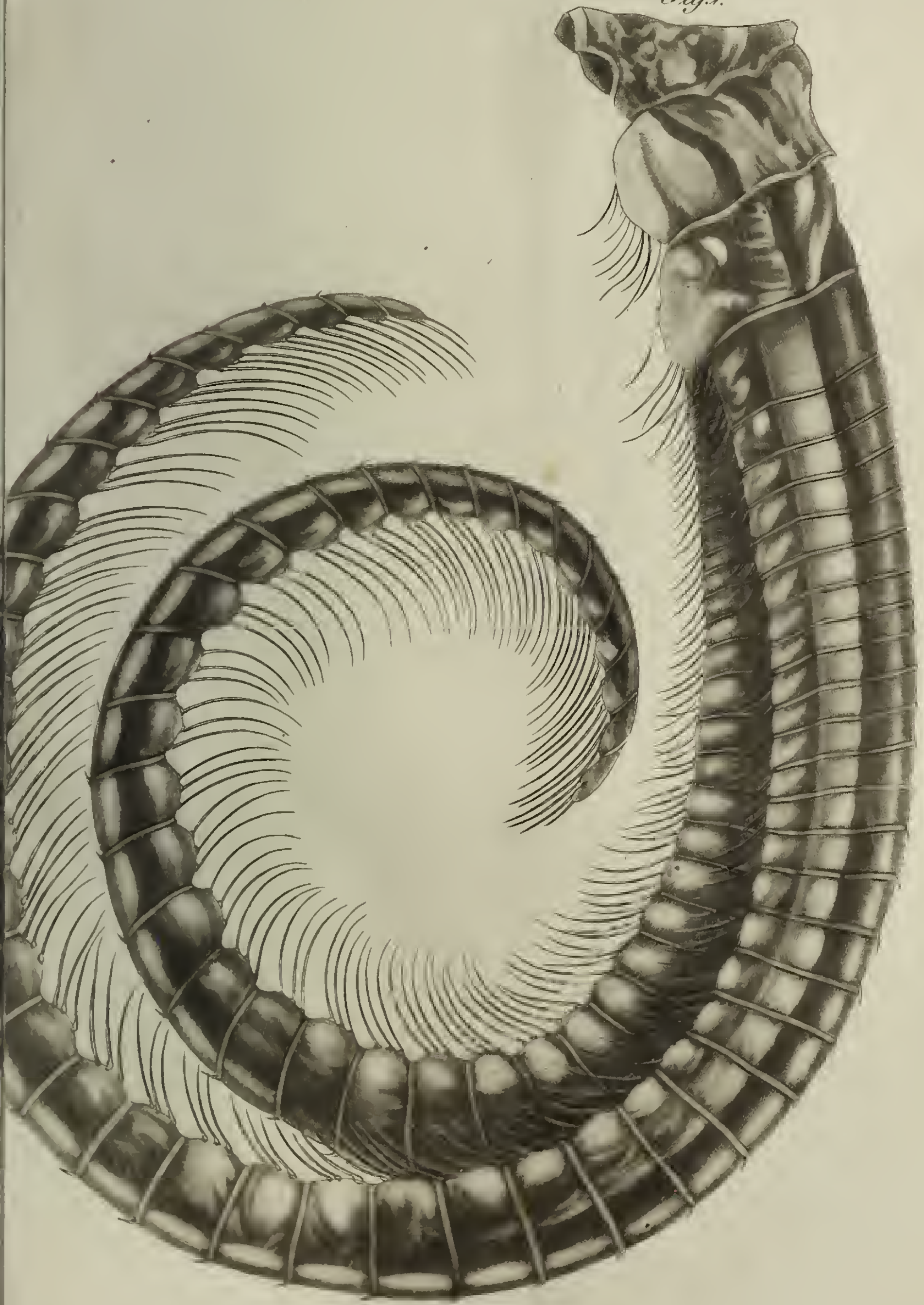

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Plate 14.

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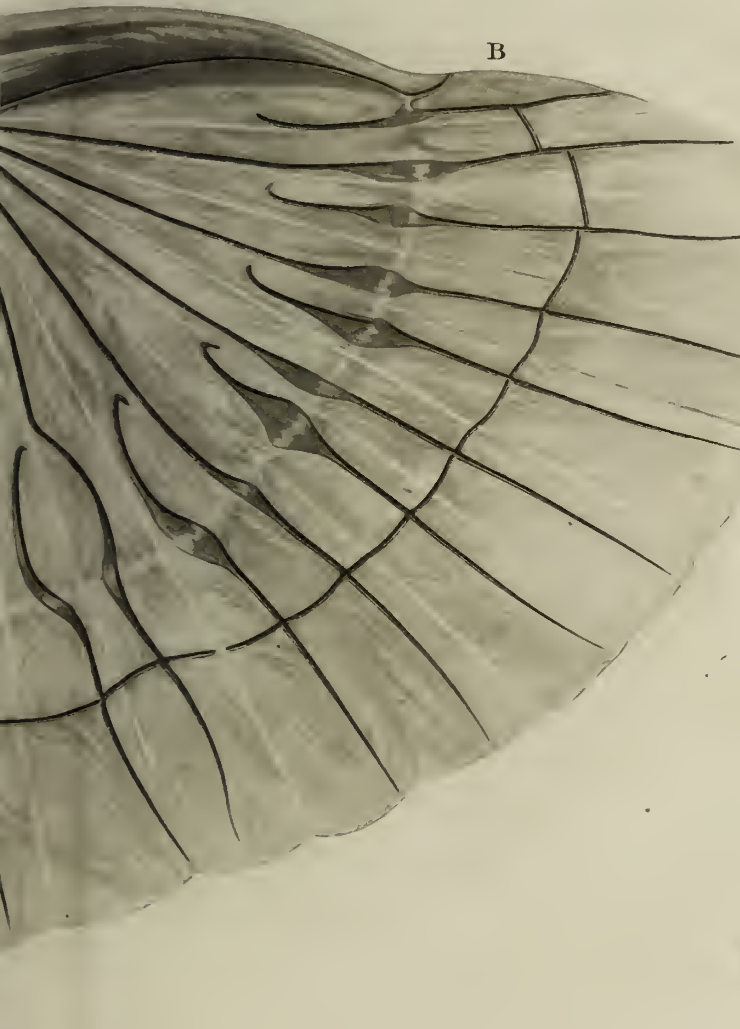
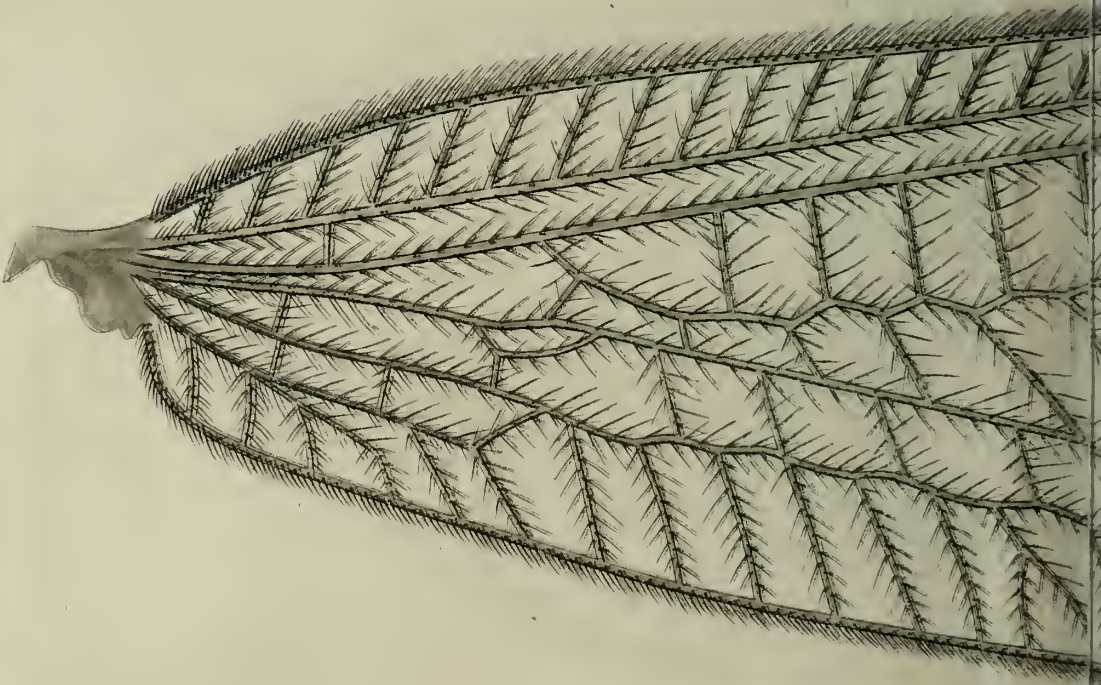


Fig. 2.

Adams Nº 60 Fleet Street May 20th 1787.

Fig. 1.



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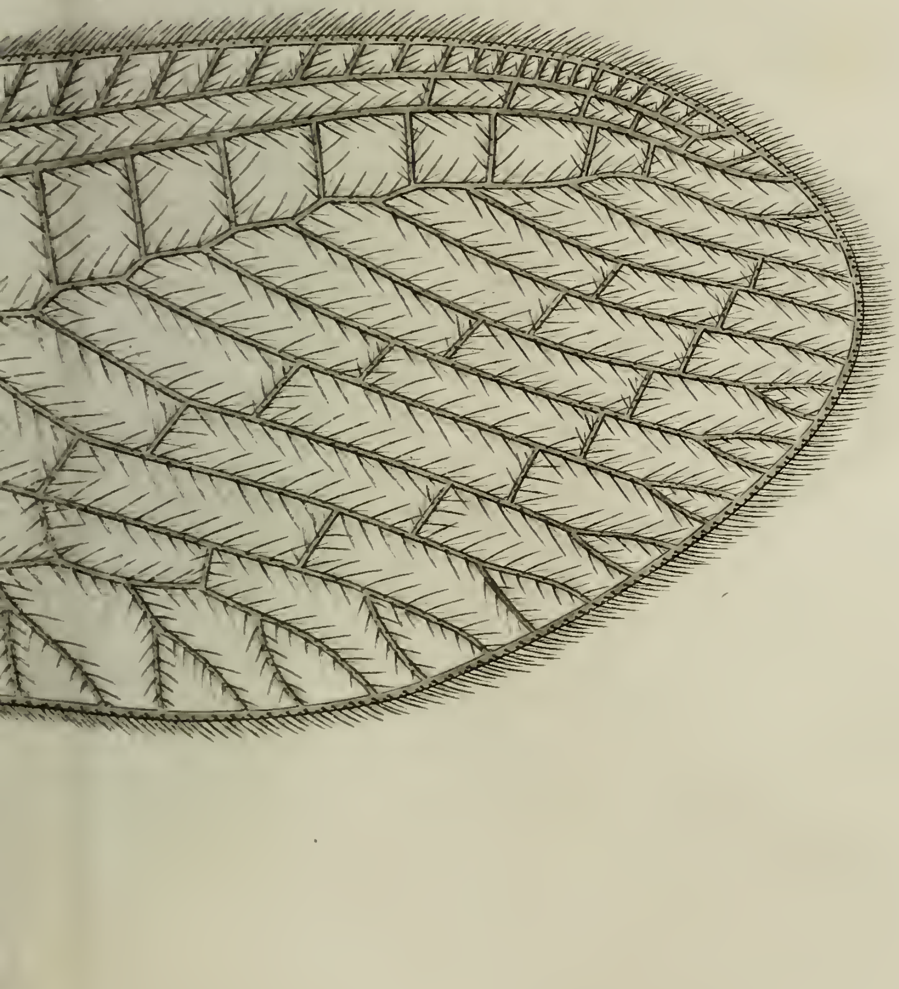
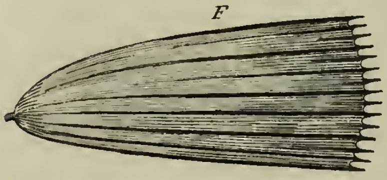
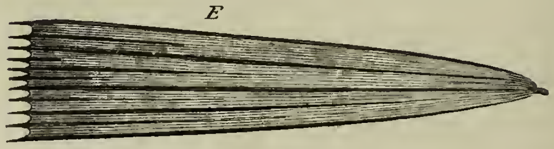






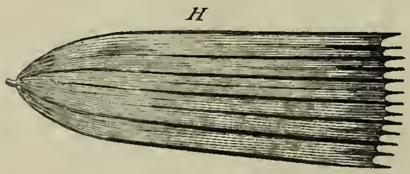
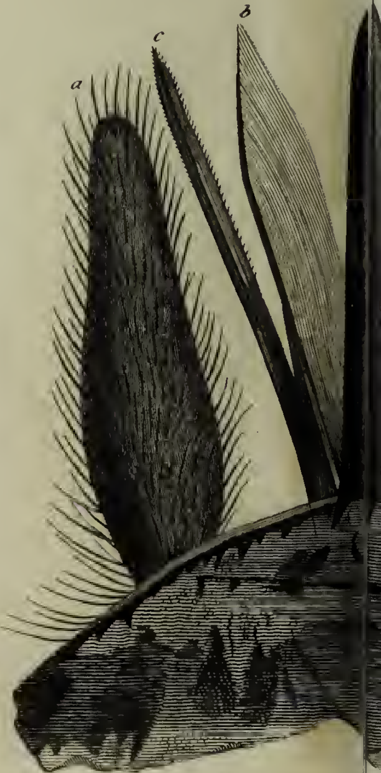


Fig.1



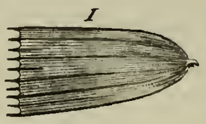
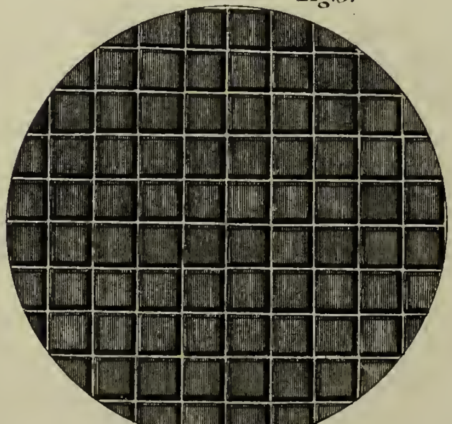


Fig.6.

Fig.5.



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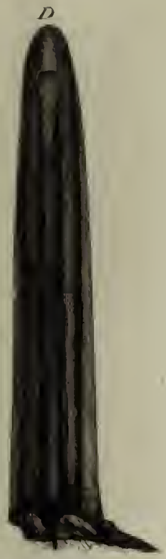

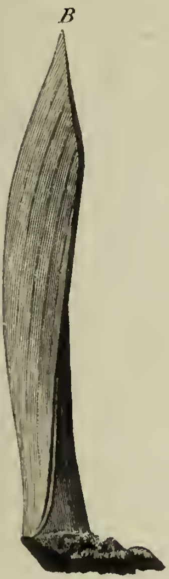

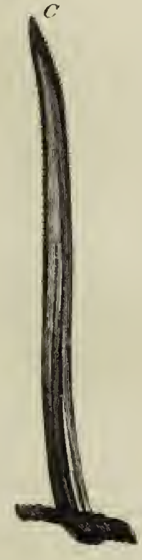

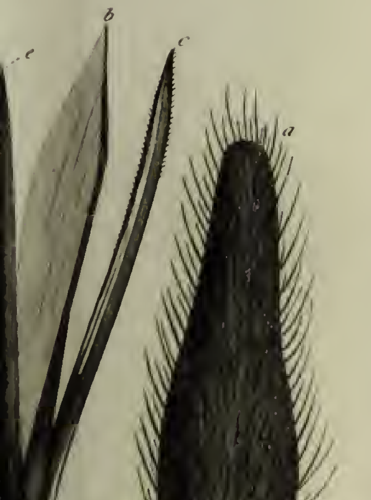

Fig. 2.

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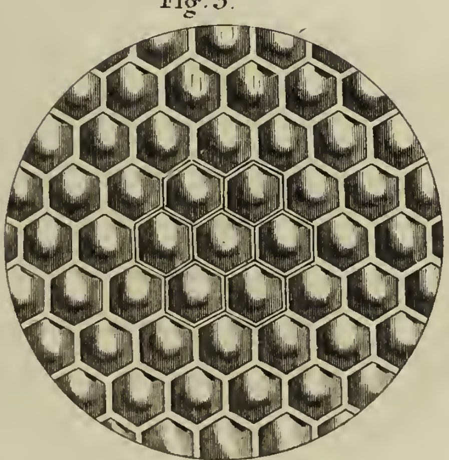

Fleet-street as the Act directs. May 20.1787

Jn. Lodge sc

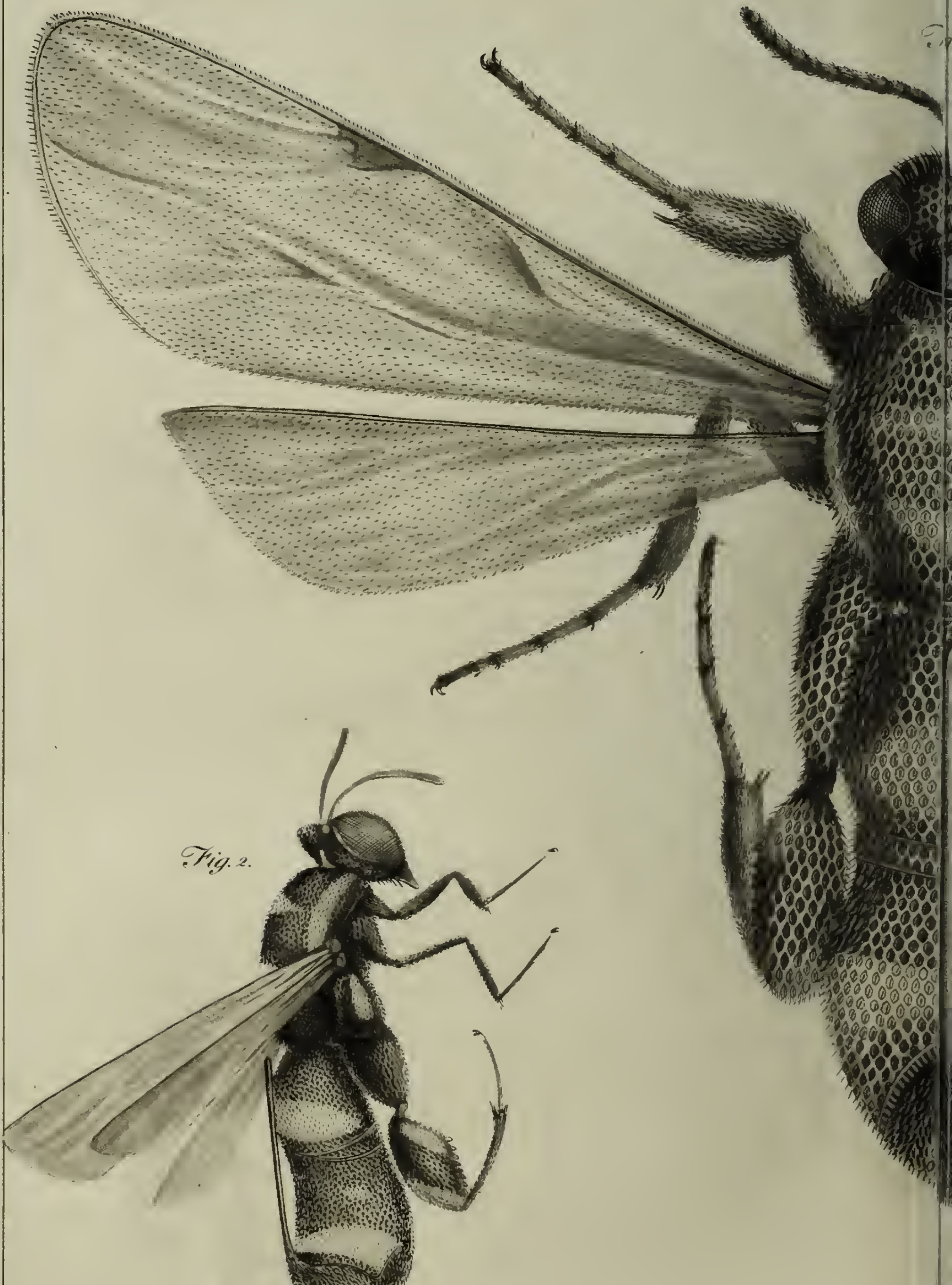
Fig. 2.

*Plate 17.*

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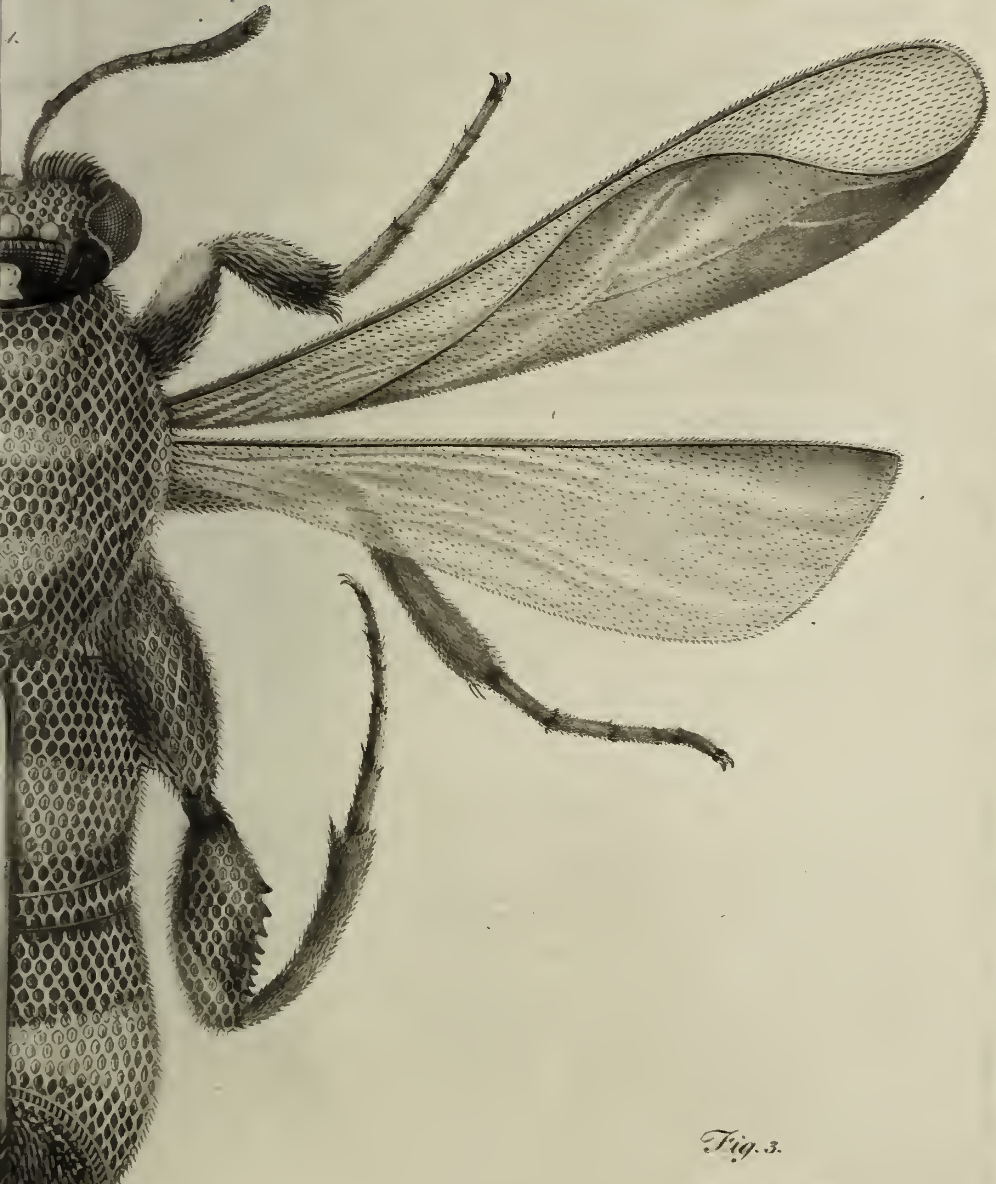

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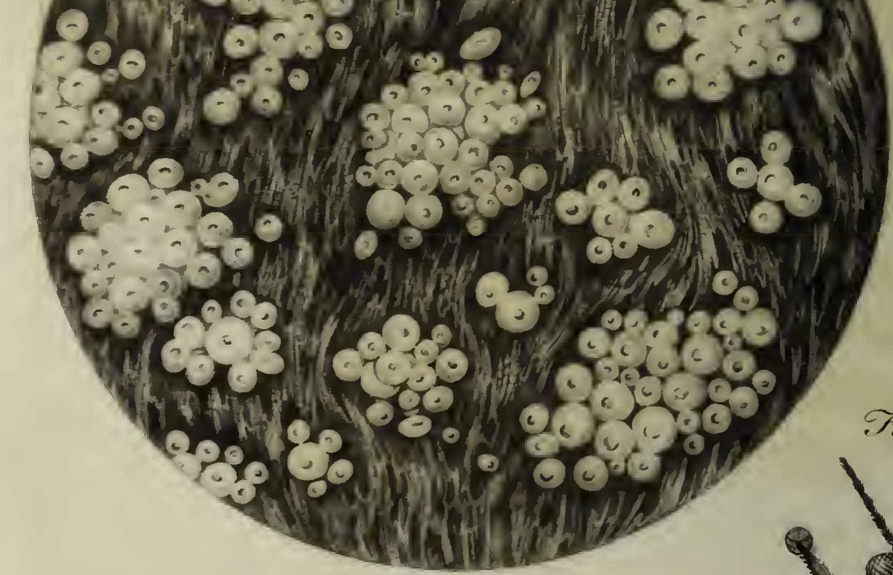

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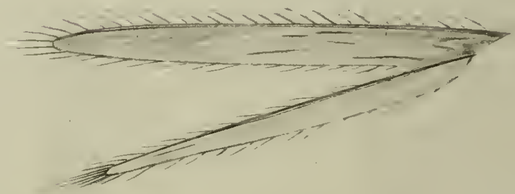

Fig. 5.

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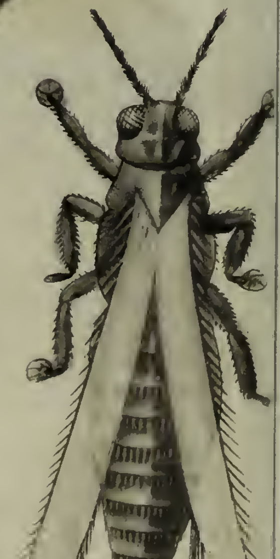

Plate 18.

Fig. 1.

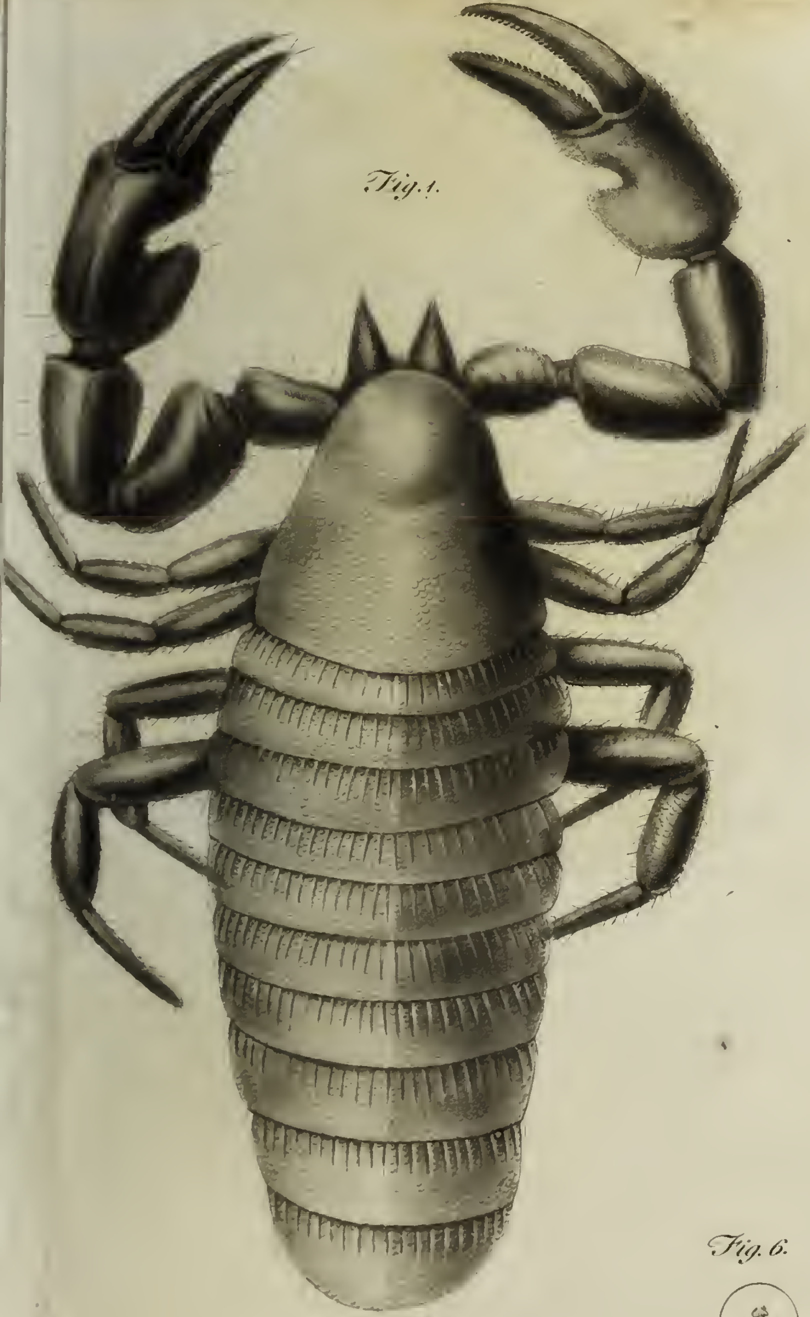

Fig. 6.

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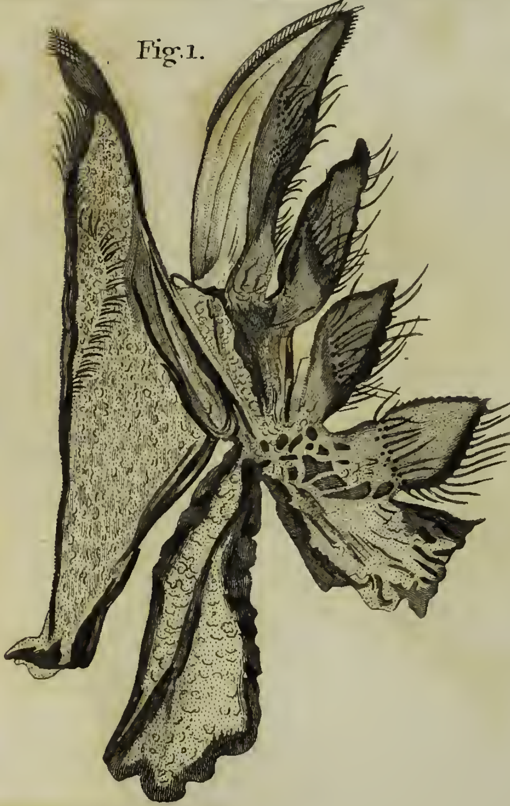

Fig. 2.

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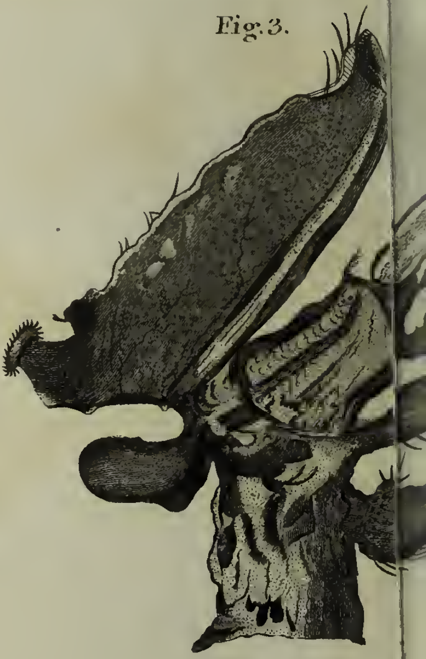

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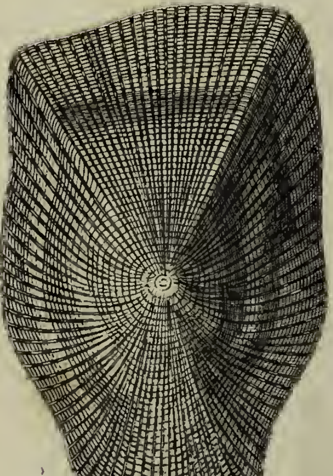

Fig. 8.

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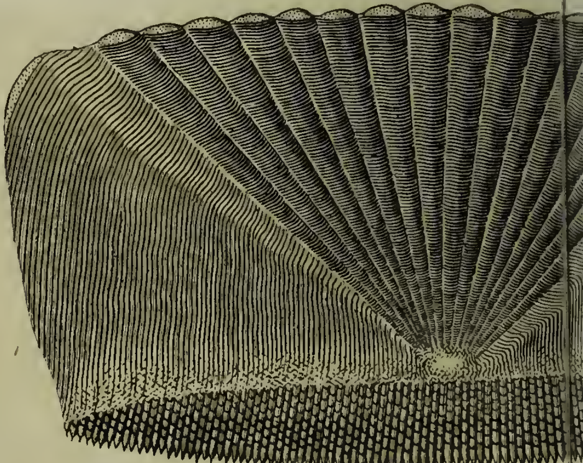

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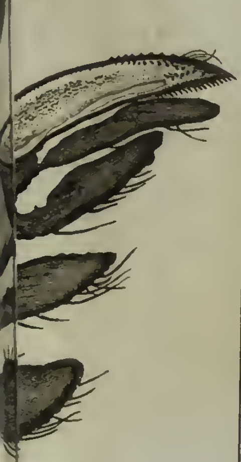
Fig. 4.



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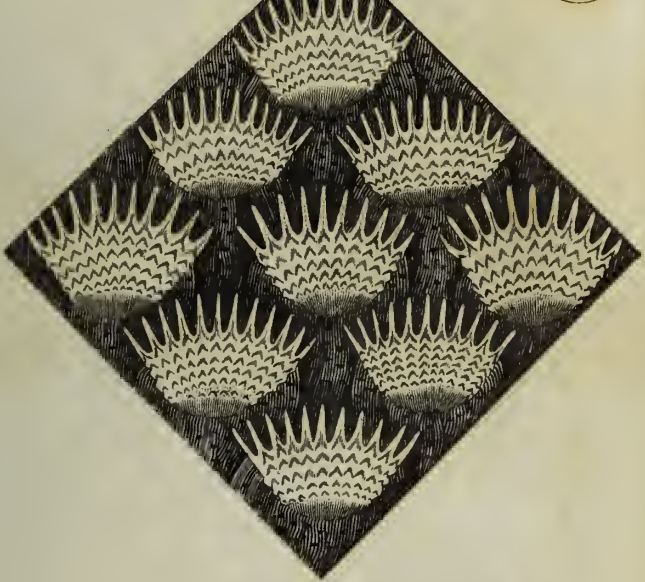

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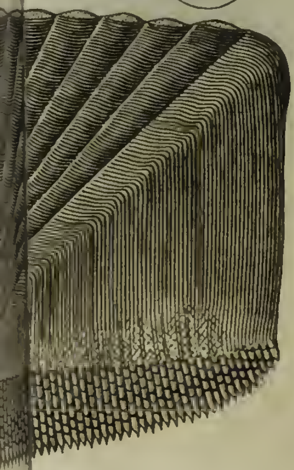

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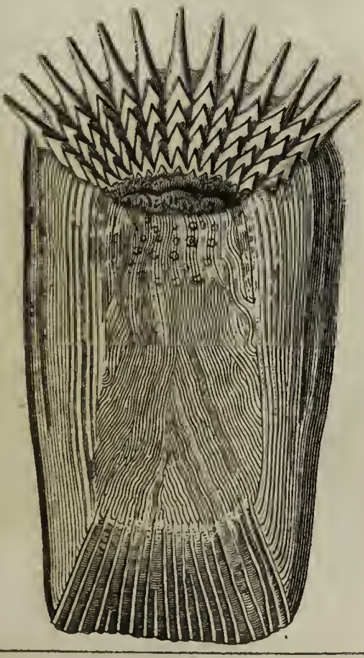

Fig. 12.

*s the act directs. May 20. 1787.*

*Jnº Lodge sc.*

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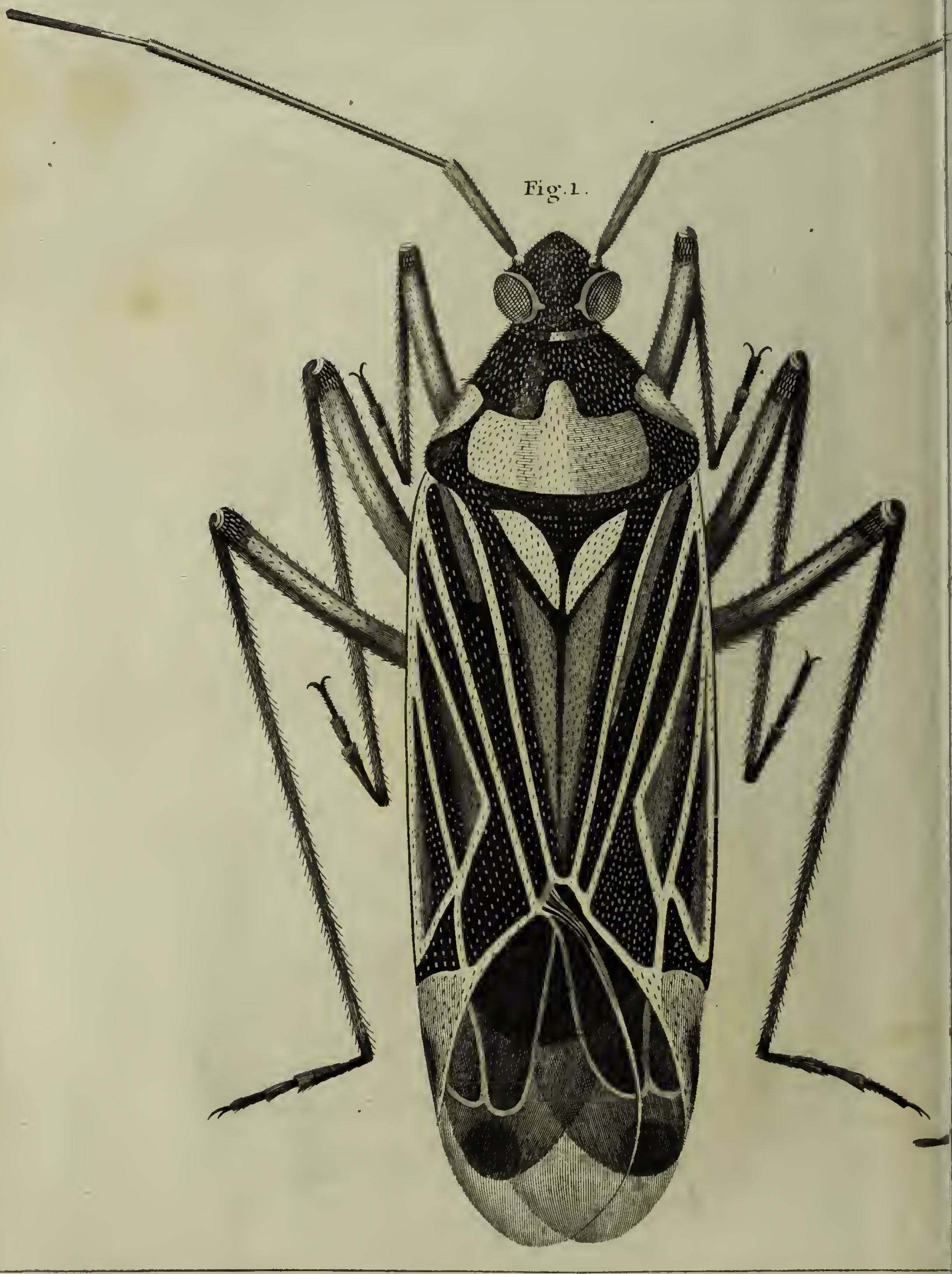

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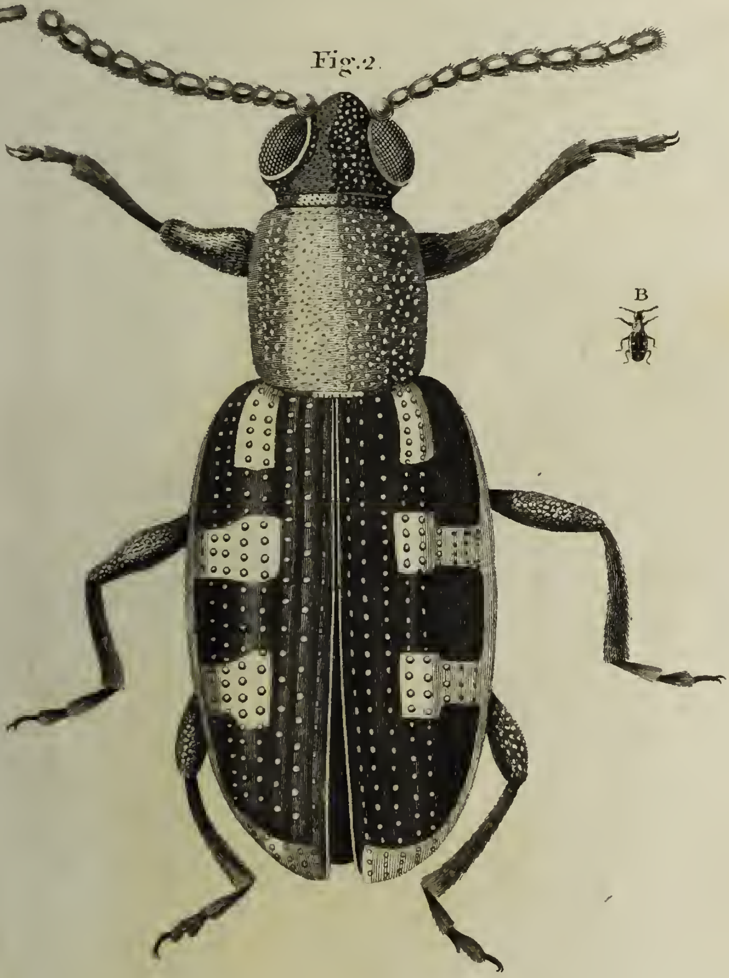
PLATE XX.

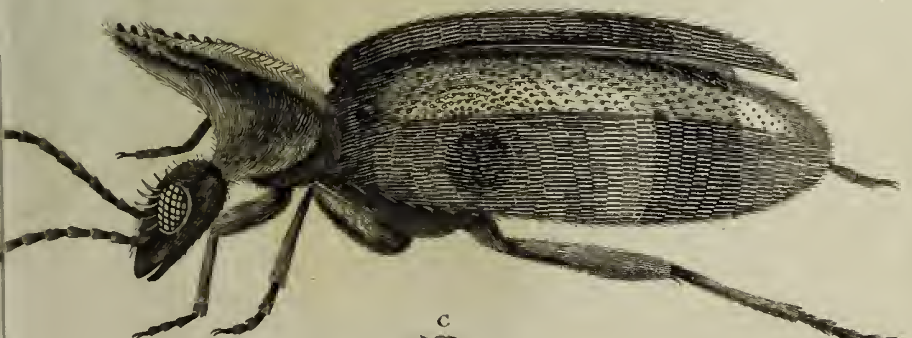
Fig. 2.



A

B

Fig. 3.



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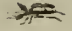
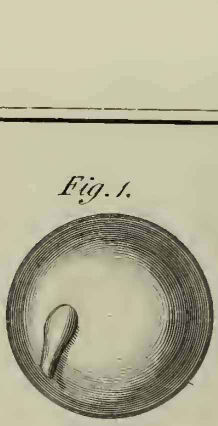


Jn.o Lodge sc.

*et Street, as the Act directs. May 20.1787.*

Fig. 1.



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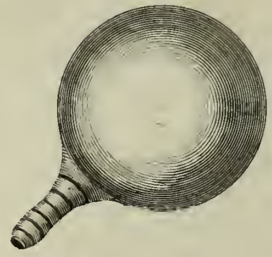

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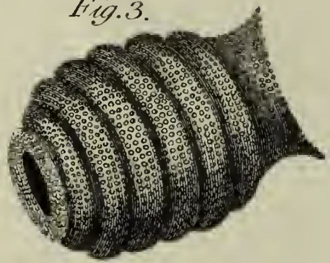

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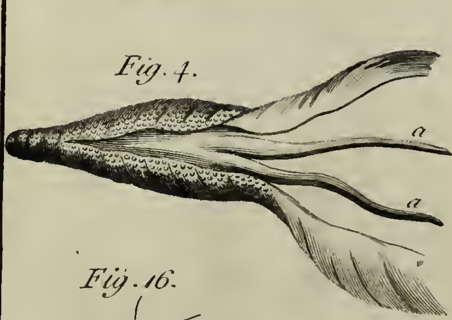

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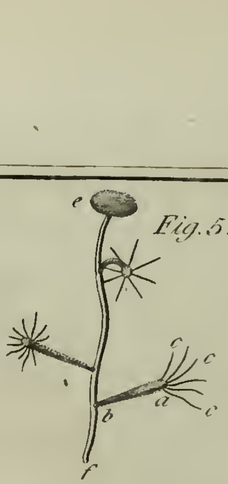

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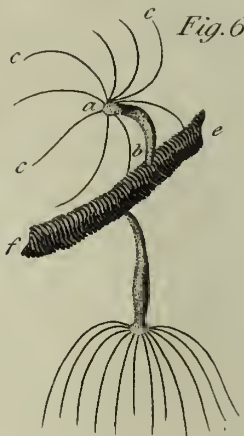

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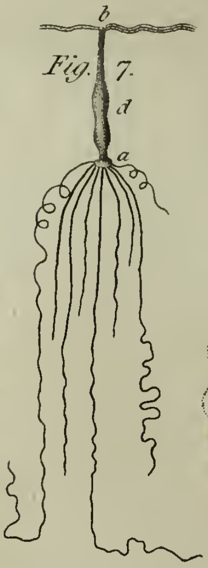
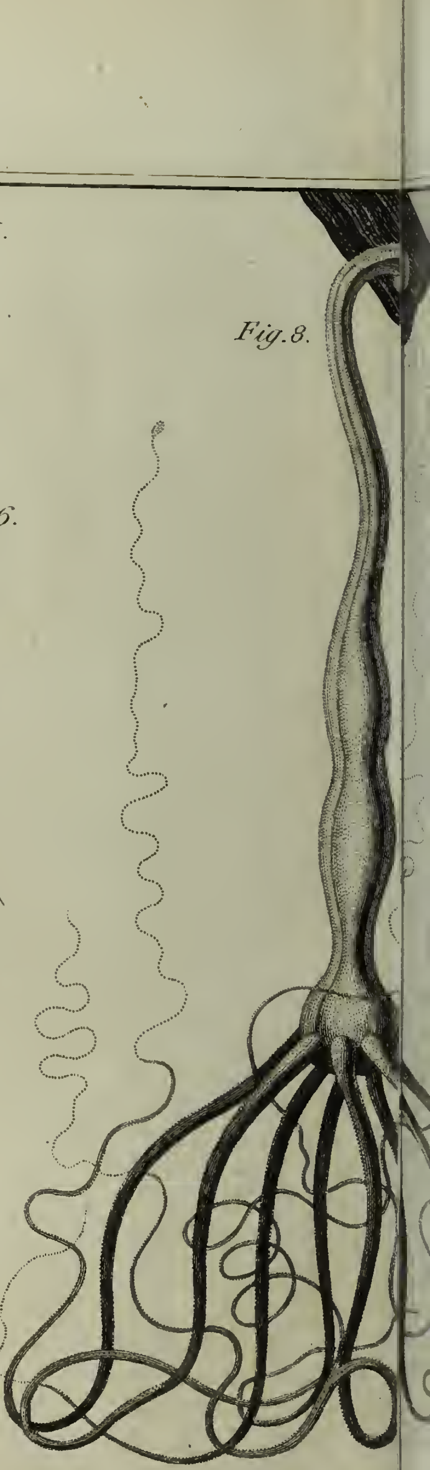


Fig. 8.



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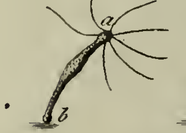

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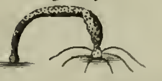

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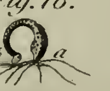

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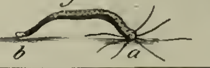

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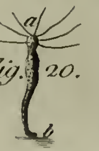

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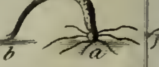

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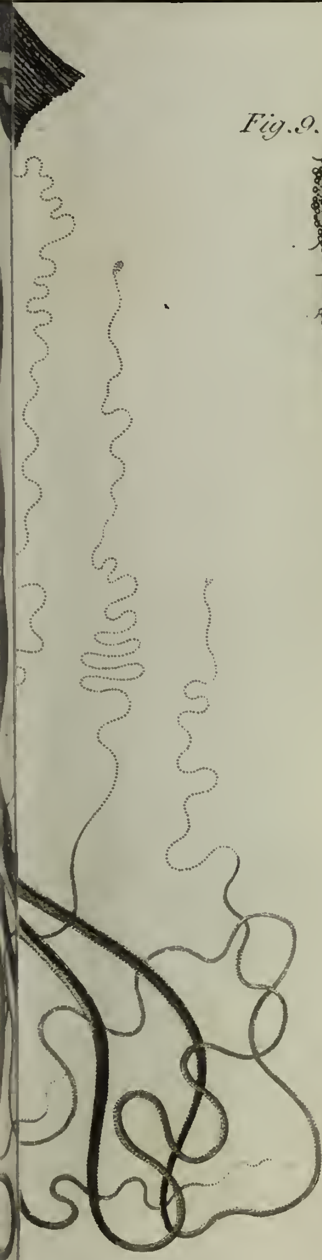

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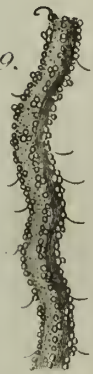

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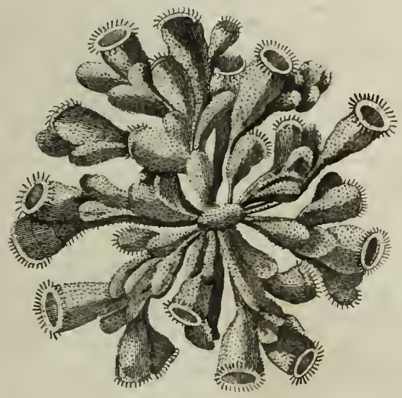

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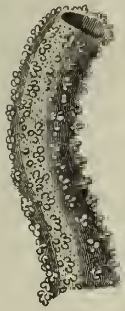

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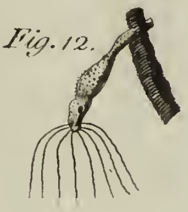

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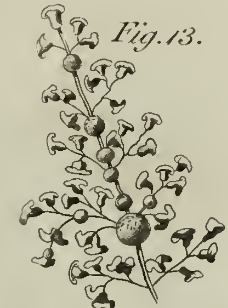

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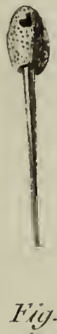

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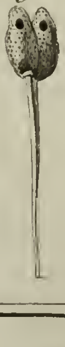

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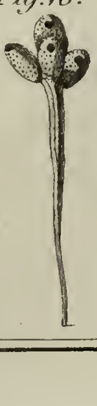

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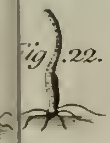

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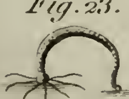

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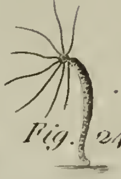
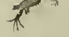


s N°. Fleet Street, as the Act directs, May 20.1787.

Jn. Lodge sc.

Fig. 25.



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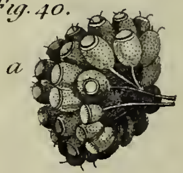

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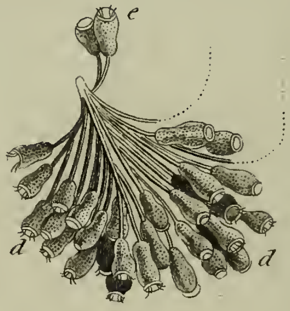

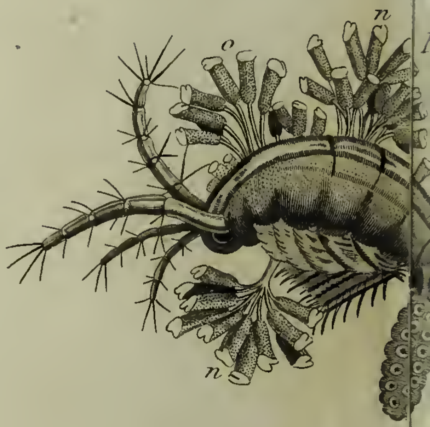

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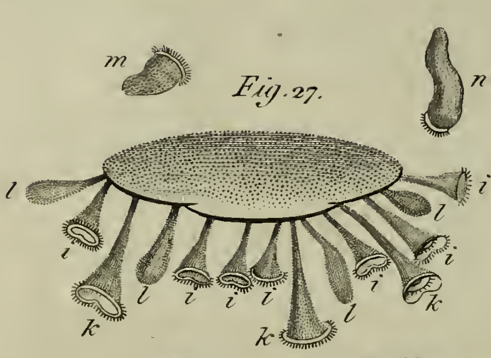

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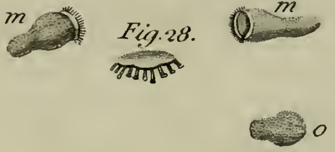

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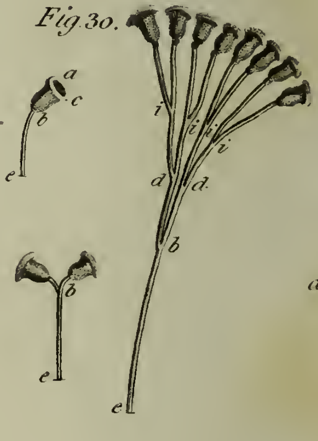

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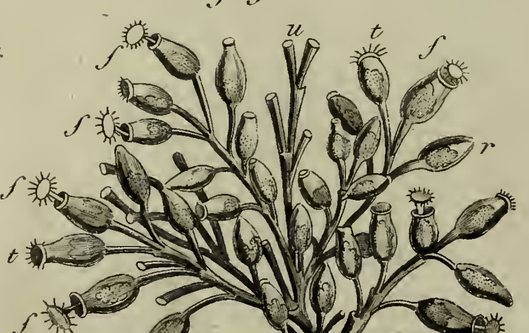

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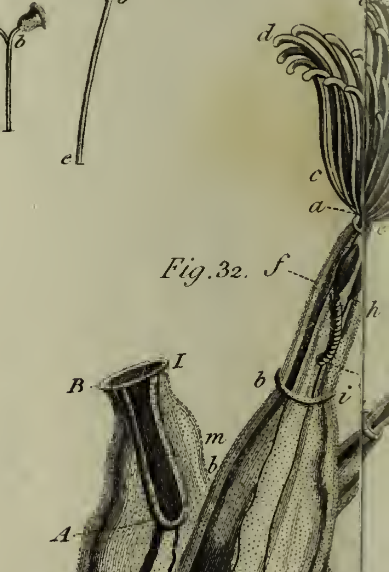

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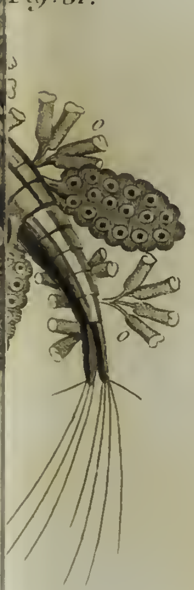
Fig. 31.



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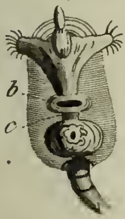

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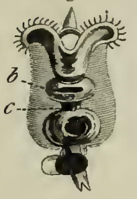

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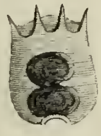

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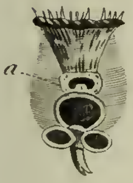

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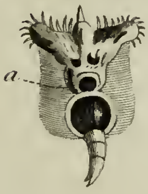

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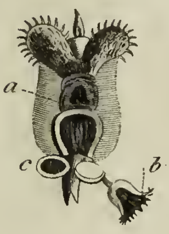

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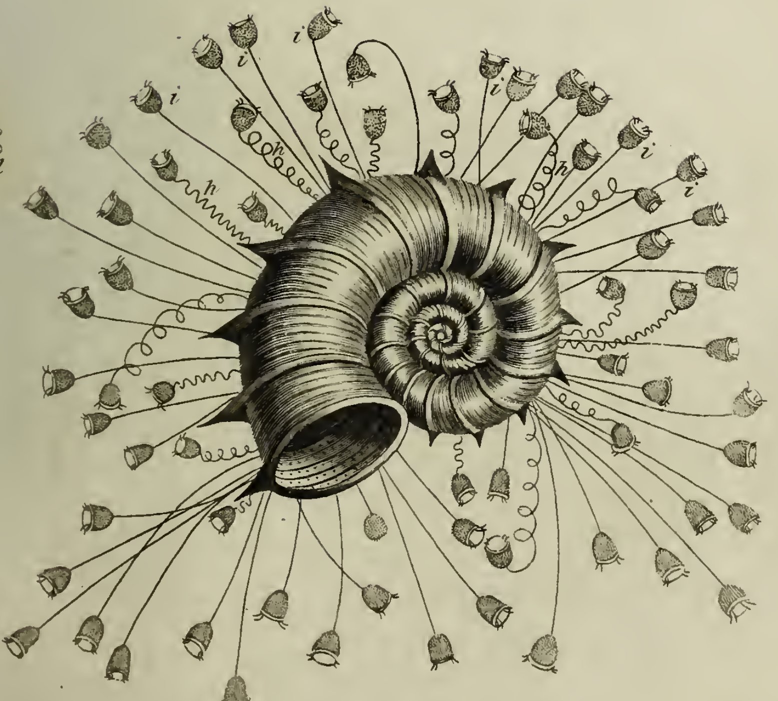
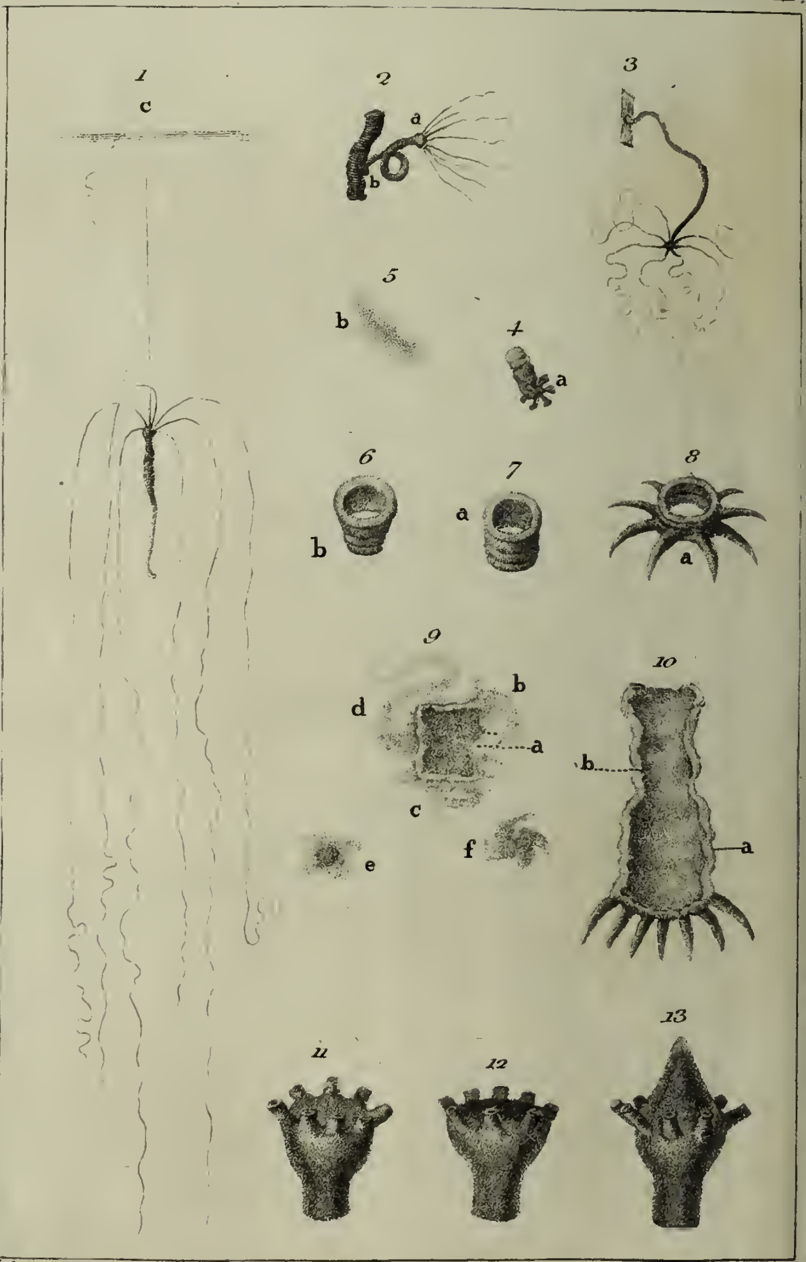


Fleet Street, as the act directs, May 20. 1787.

J. Lodge sc.

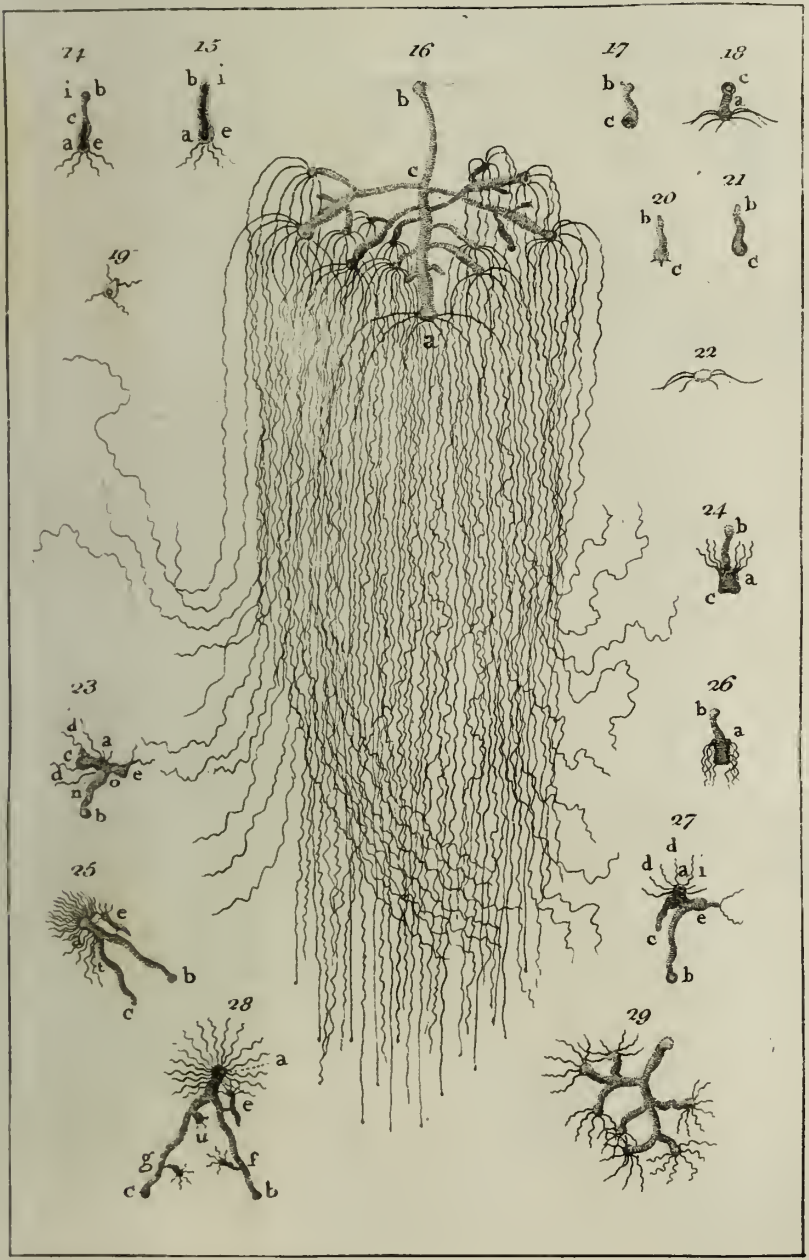
Pl. 23 A.



J. Wigley. Sc.

London. Printed for & Published by George Adams, No

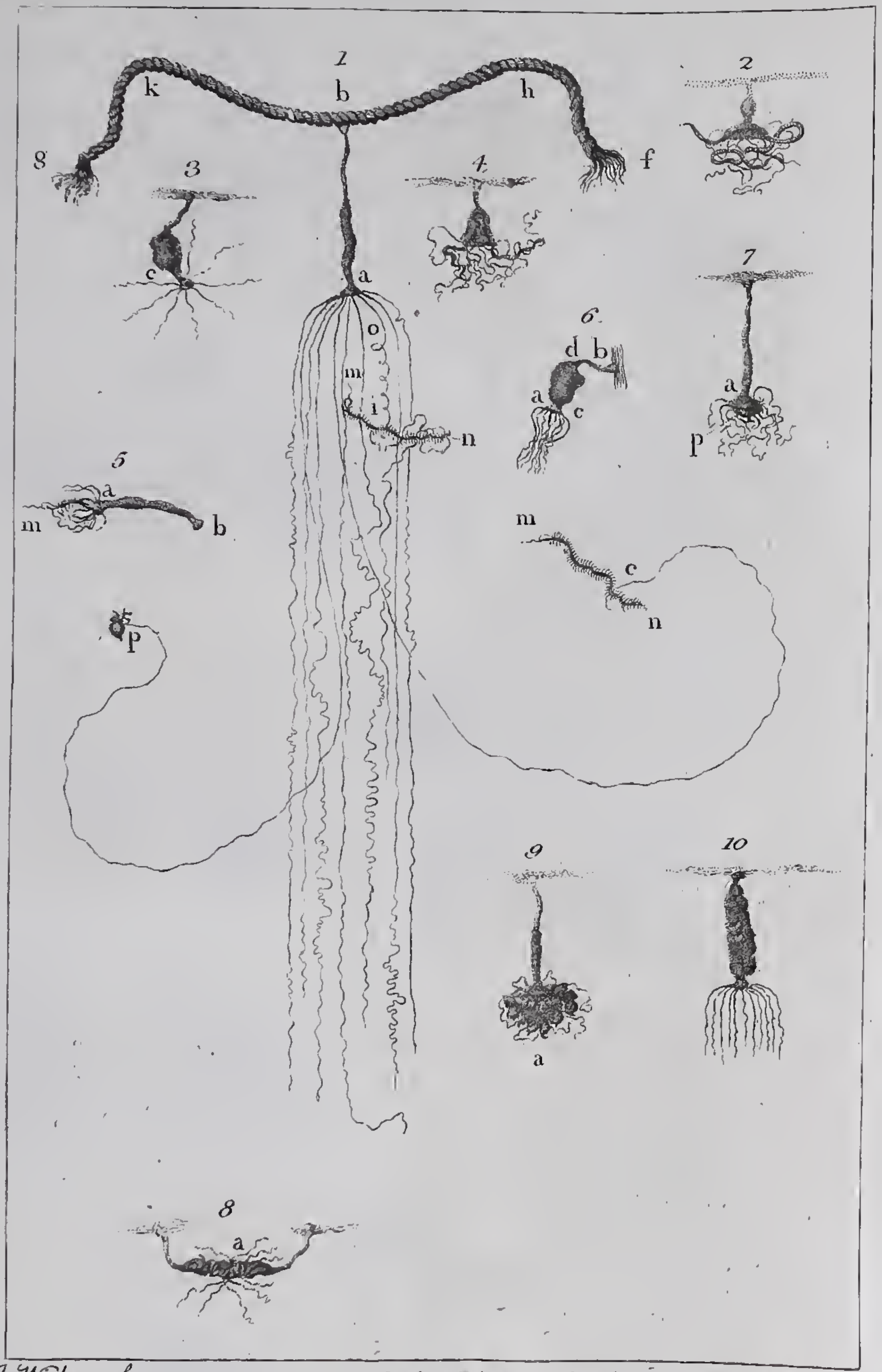
*Pl. 23 B.*



*60, Fleet Street. as the act directs 20 May 1787.*

*Bowles sc.*

*Pl. 24 A.*



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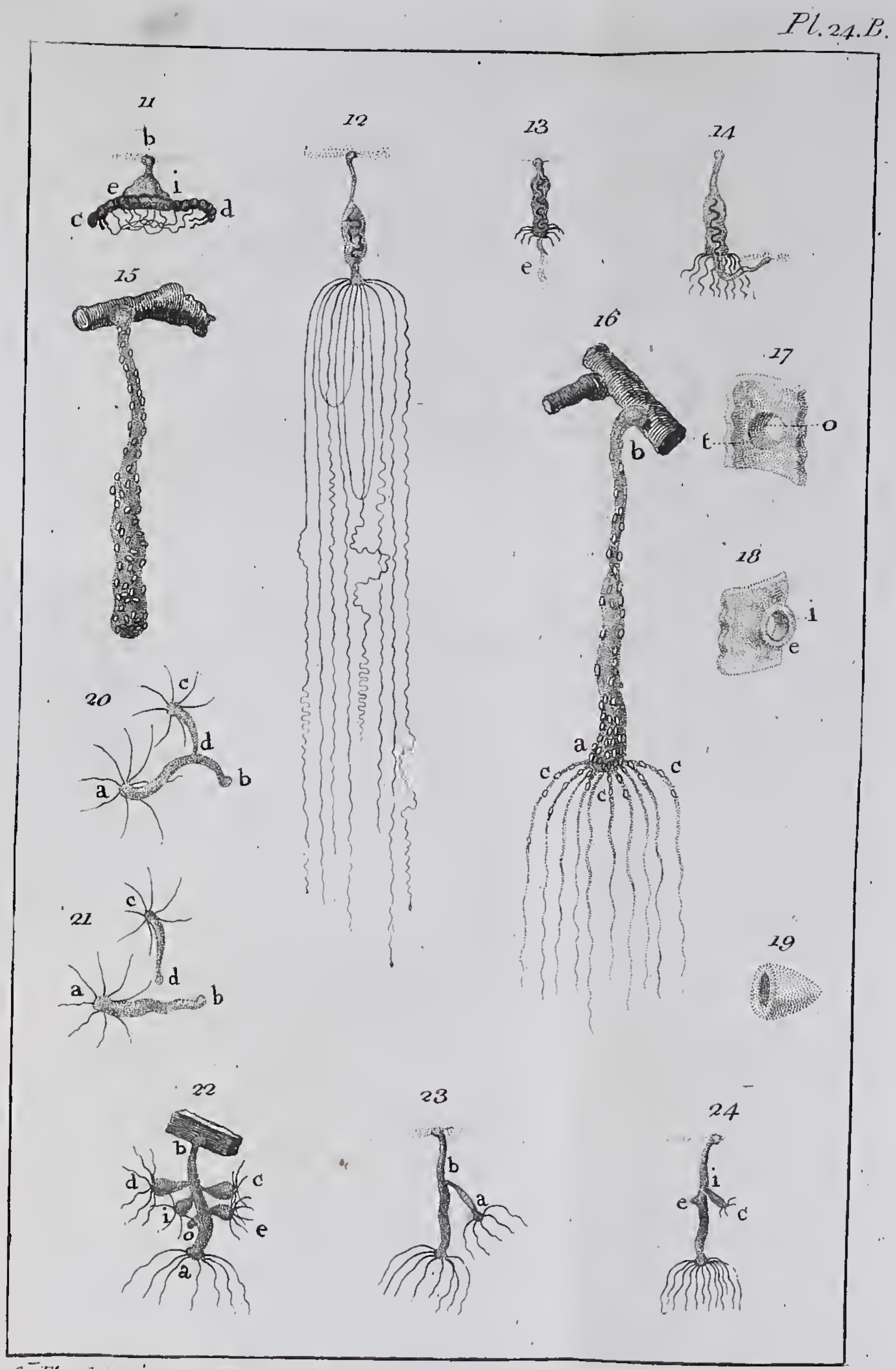
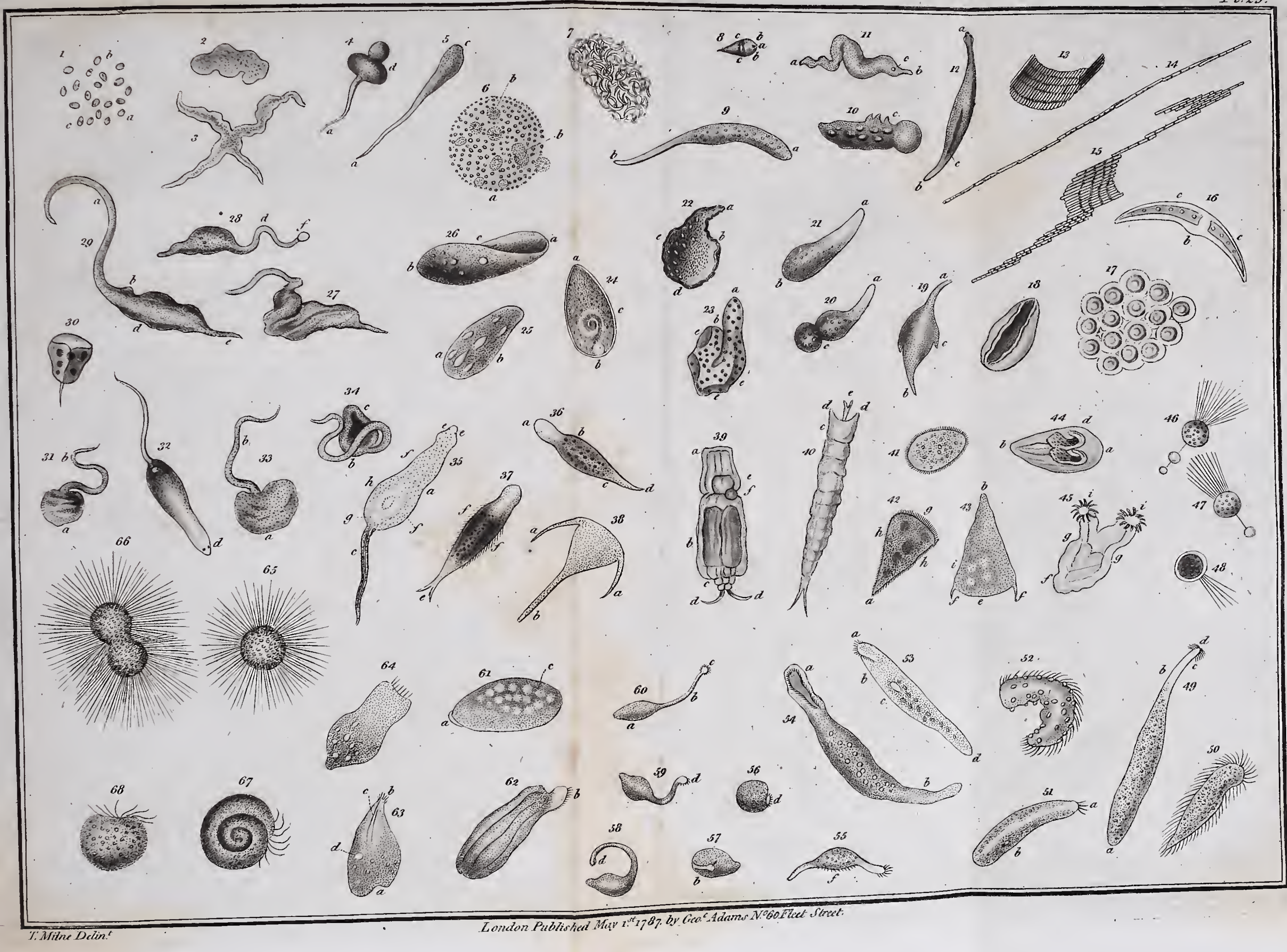


*J. Wigley. Sc.*

London. *Printed for & Published by* George Adams, *No 60 Fleet Street, as the act directs 20 May 1787.*

*Bowles Sc.*

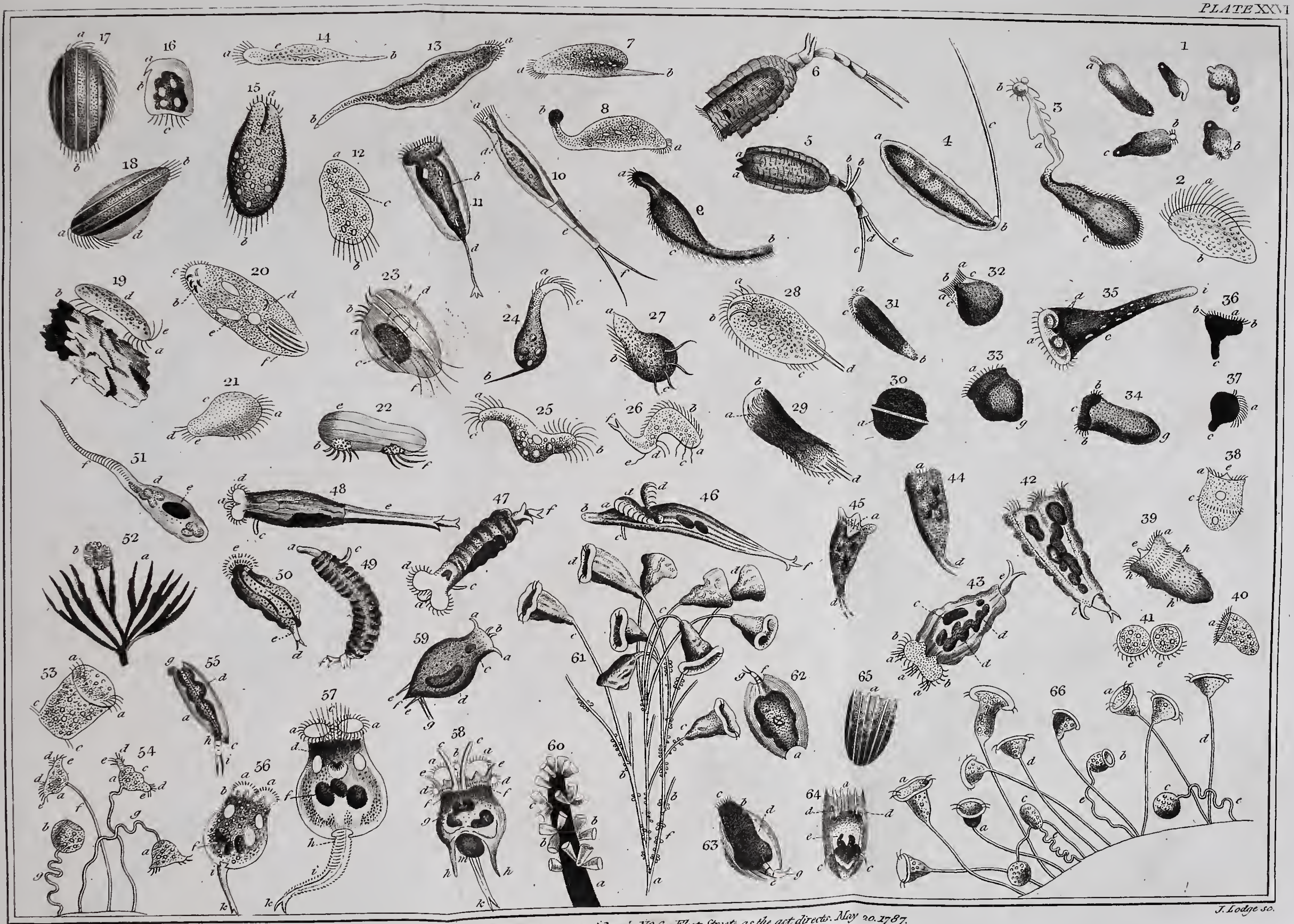
Pl. 25.



T. Milne Delin.^t

London Published May 1^st 1787, by Geo.^e Adams N^o 60 Fleet Street.

PLATE XXVI

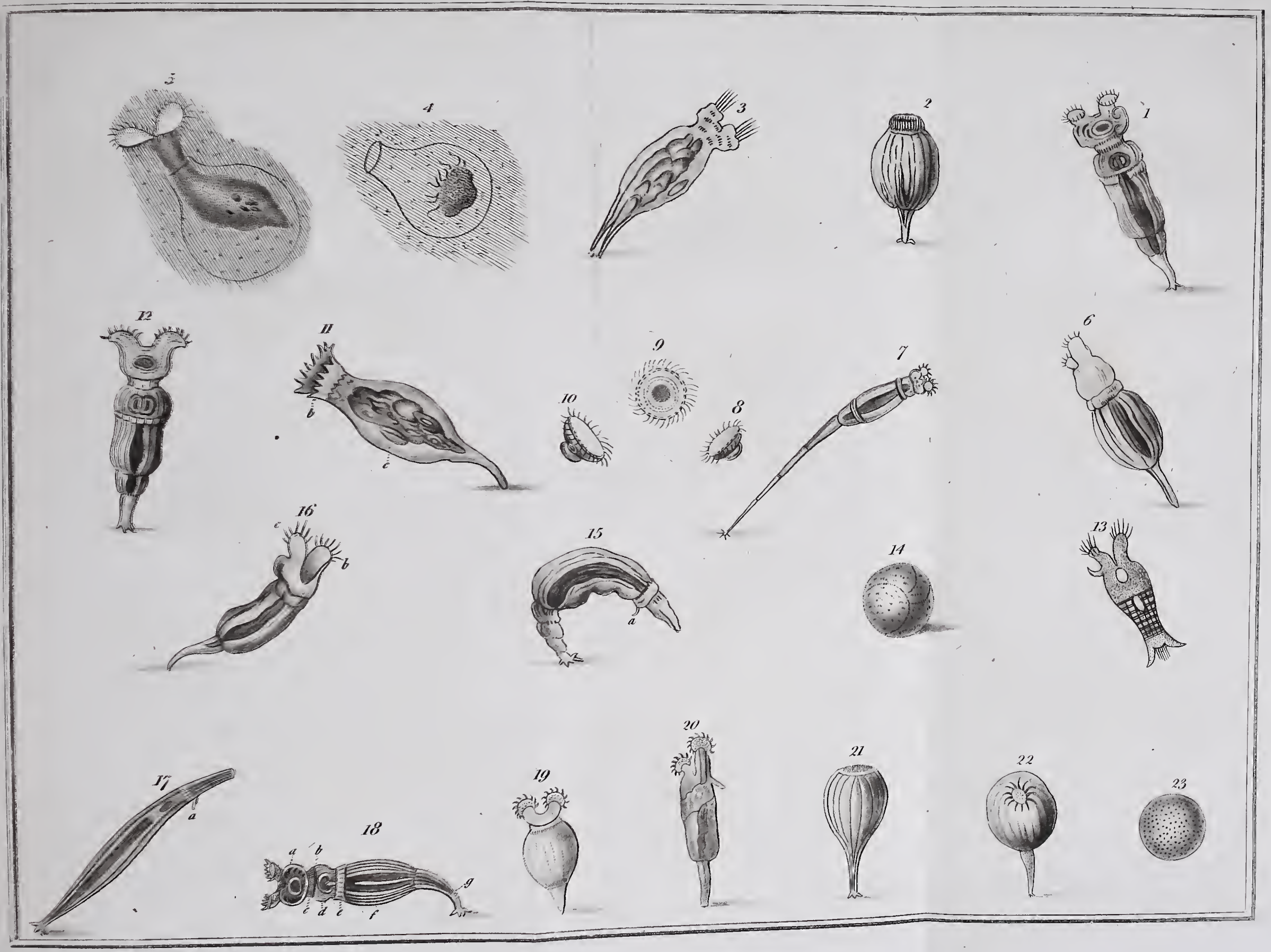


T. Milne del.

J. Lodge sc.

London. Printed for & Published by George Adams, No. 60. Fleet Street, as the act directs. May 20. 1787.

Plate 26. A.



London Published May 1st 1787, by Geo. Adams No. 60 Fleet Street.

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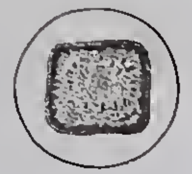

Fig. 2.

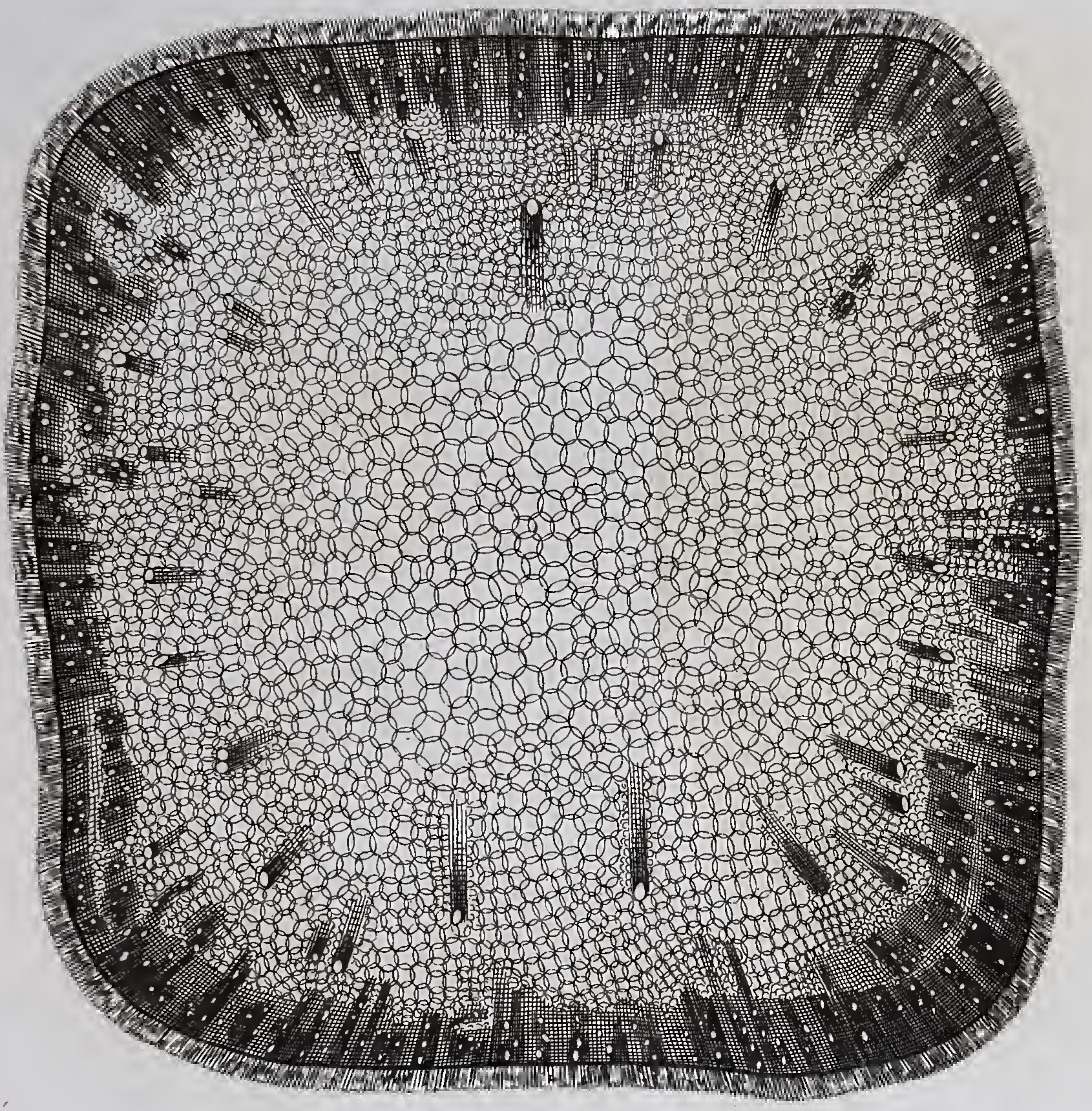

Fig. 3.

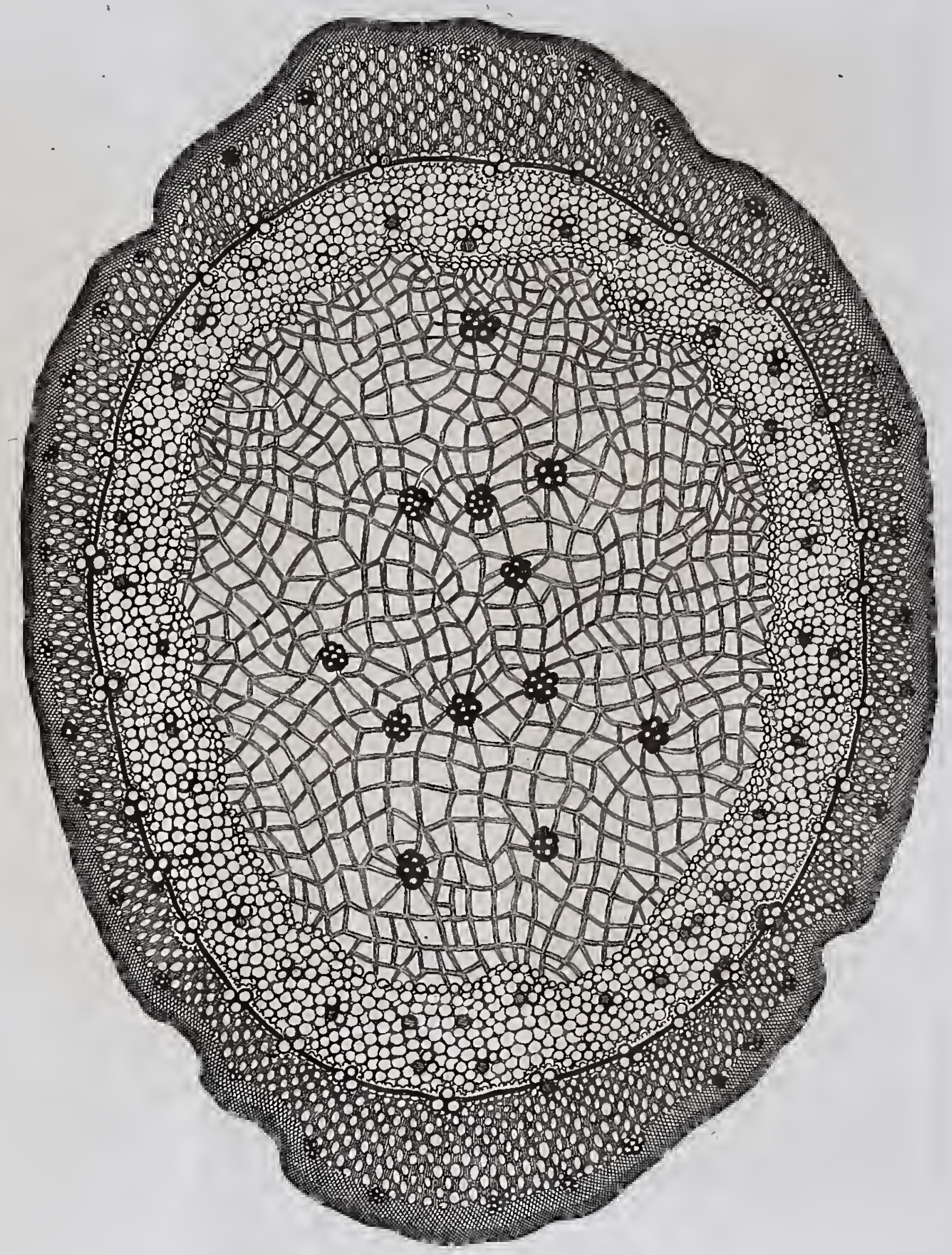

Fig. 4.

*T. Milne del.* *J. Lodge scu.*

London. *Printed for & Published by* George Adams *No. 60 Fleet Street, as the act directs. May 20. 1787.*

PLATE XXVIII

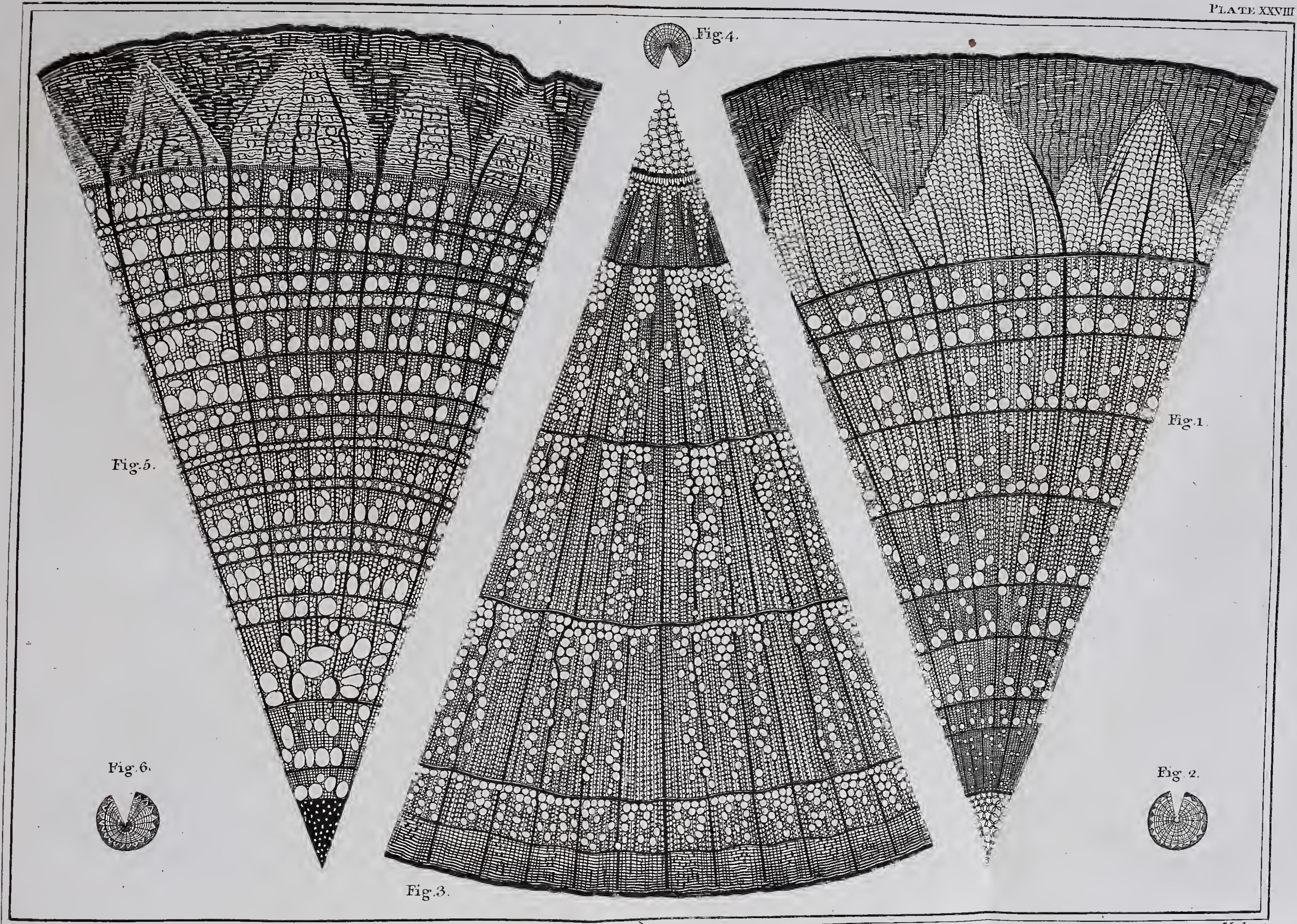
Fig.4.
Fig.5.
Fig.3.
Fig.1.
Fig.6.
Fig. 2.

*T. Milne del.*

*J. Lodge sc.*

London. *Printed for & Published by* George Adams *N.^o 60, Fleet Street, as the Act directs, May 20 1787.*

Plate 29.

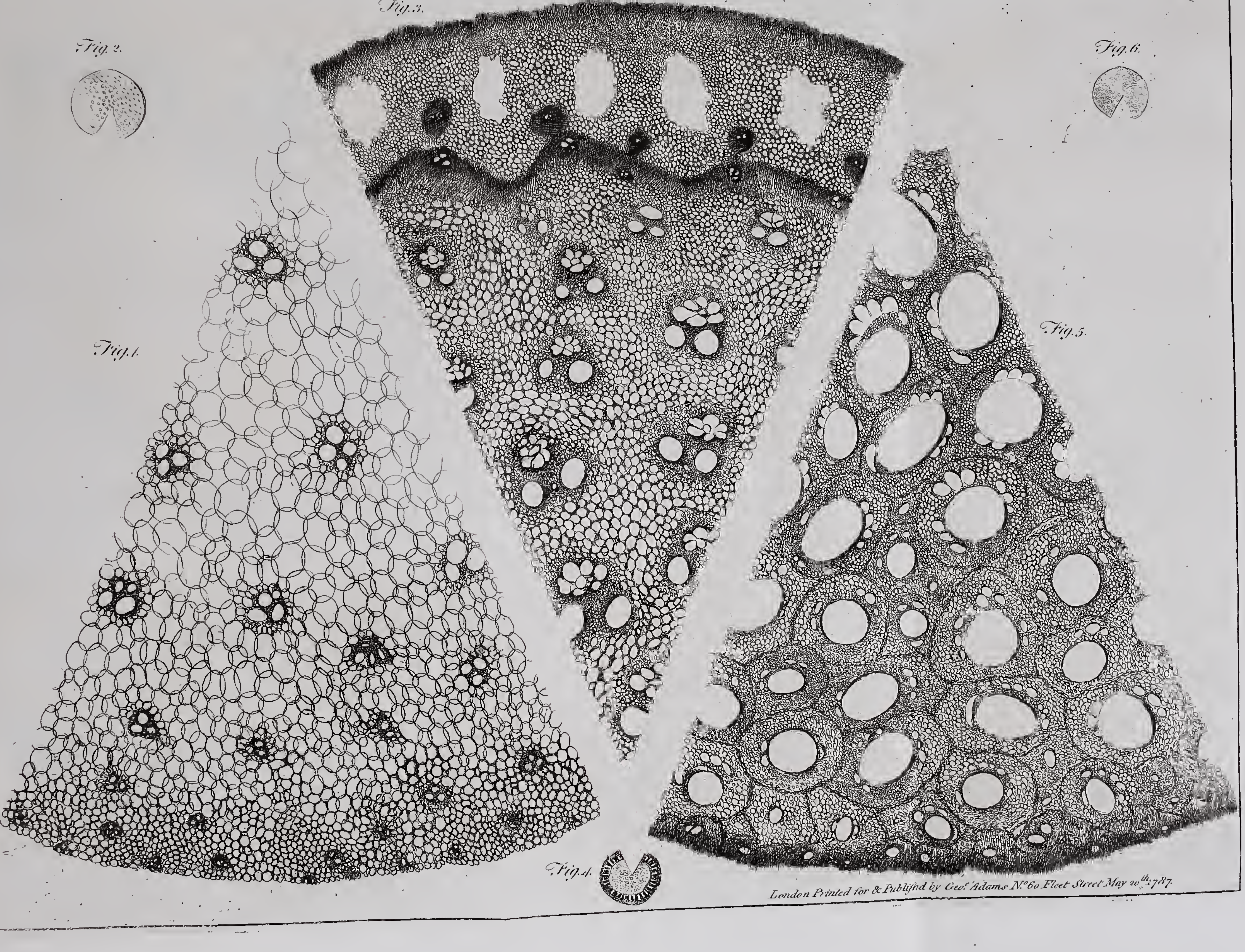
Fig. 2.
Fig. 3.
Fig. 6.
Fig. 1.
Fig. 5.
Fig. 4.

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PLATE XXX.

Fig. 2.

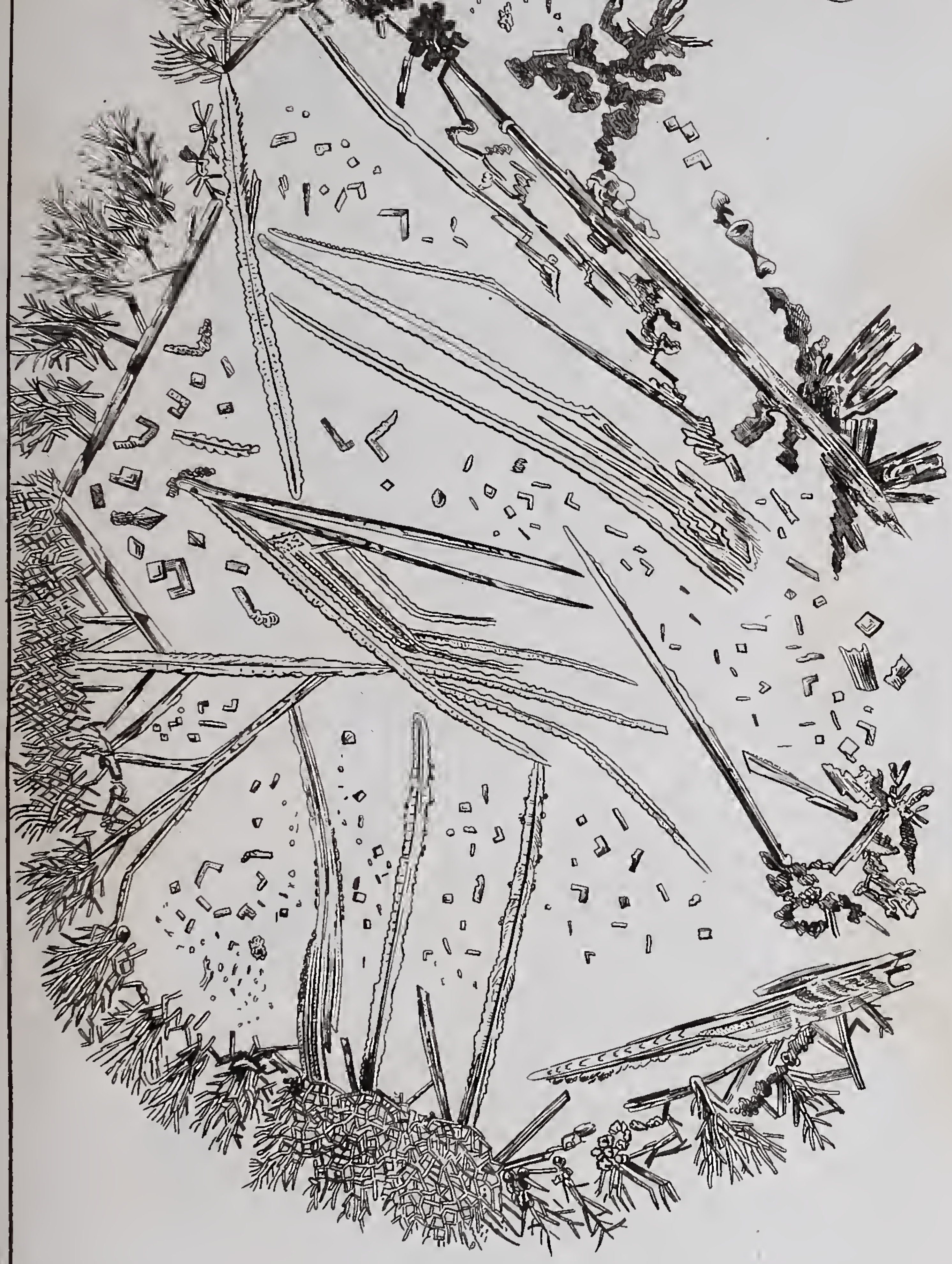
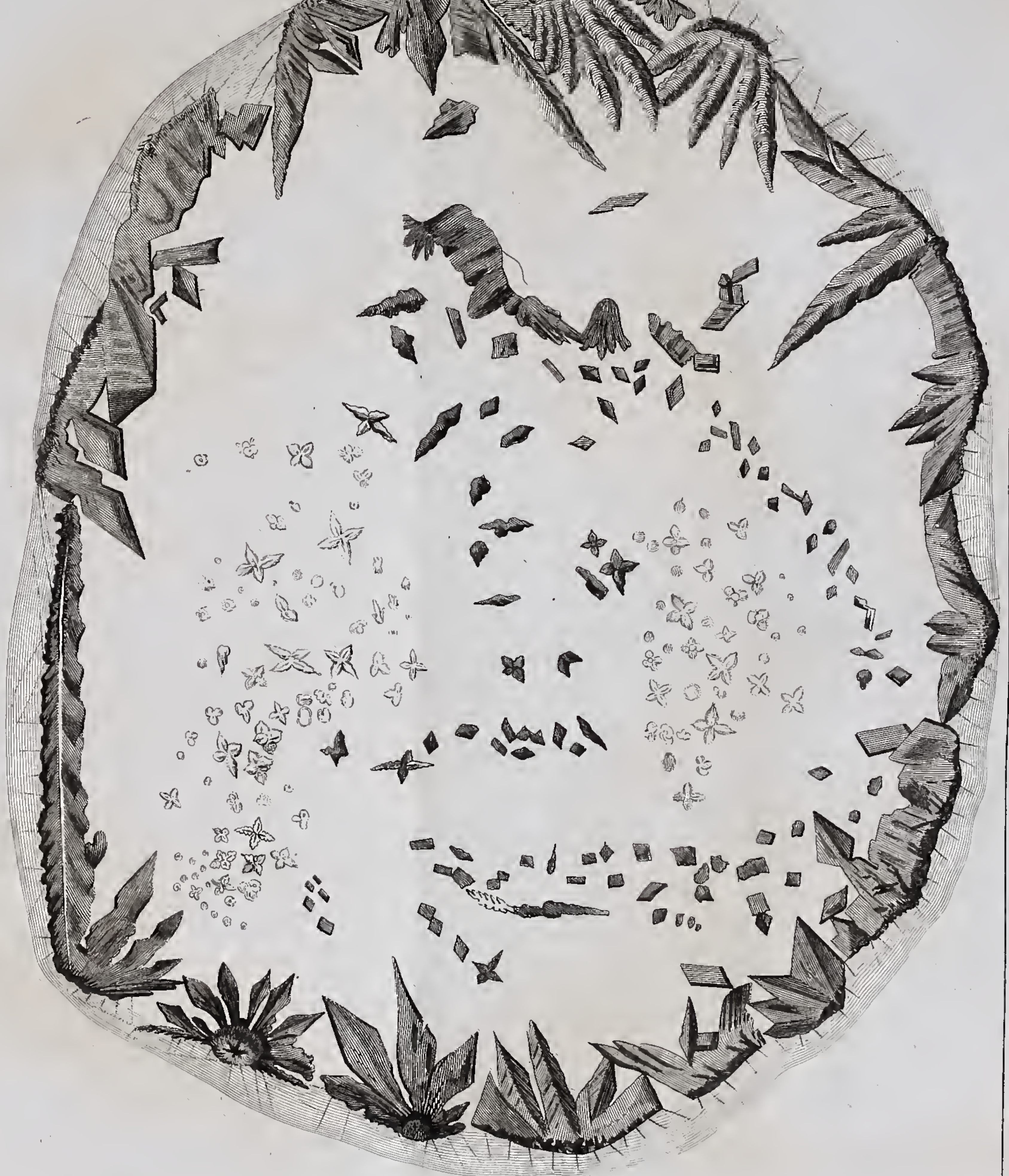


Fig. 1.

Fig. 4.



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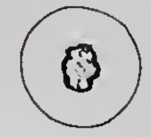

T. Milne del.

Jn. Lodge sc.

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Plate 31.

Fig. 1.

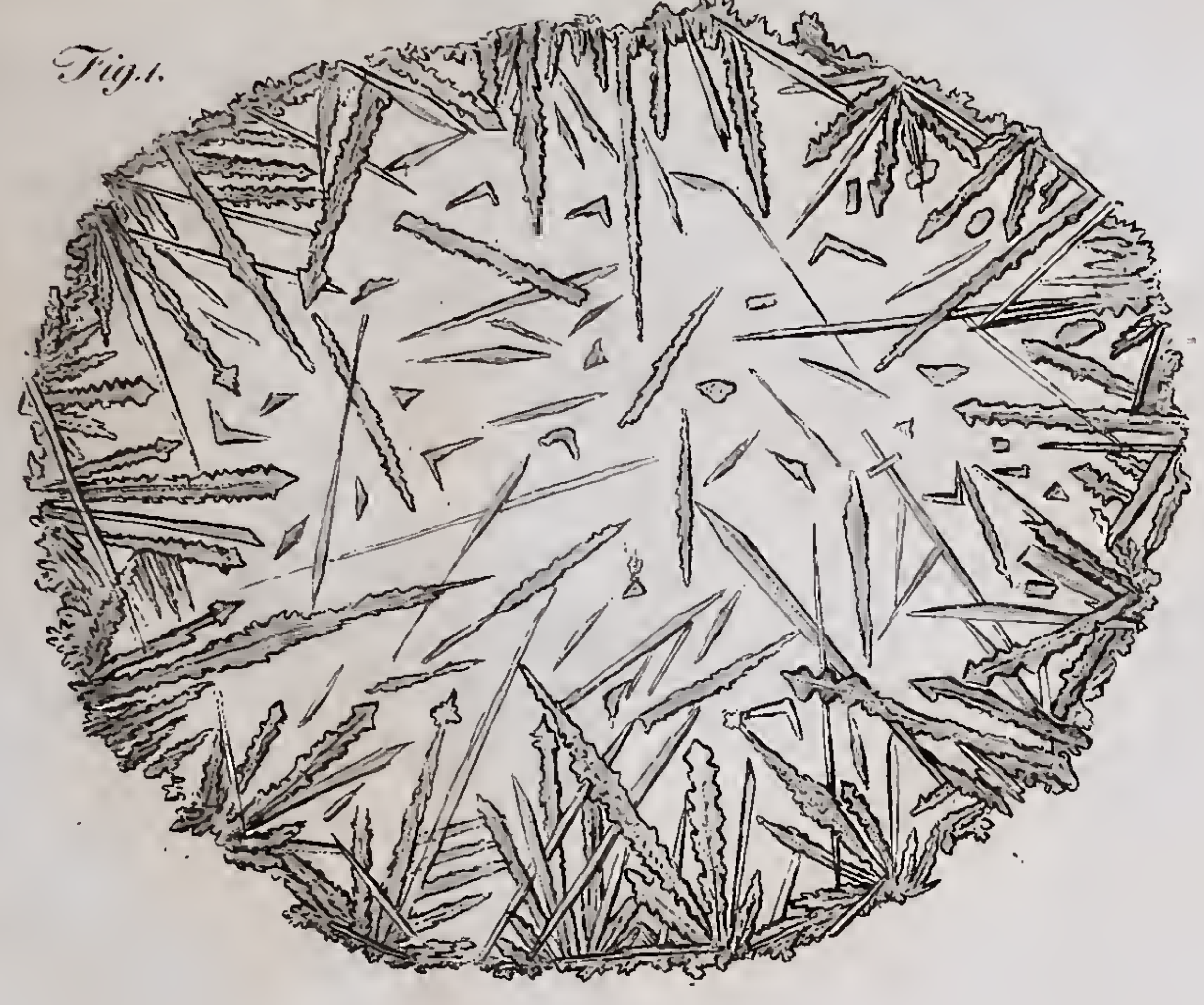
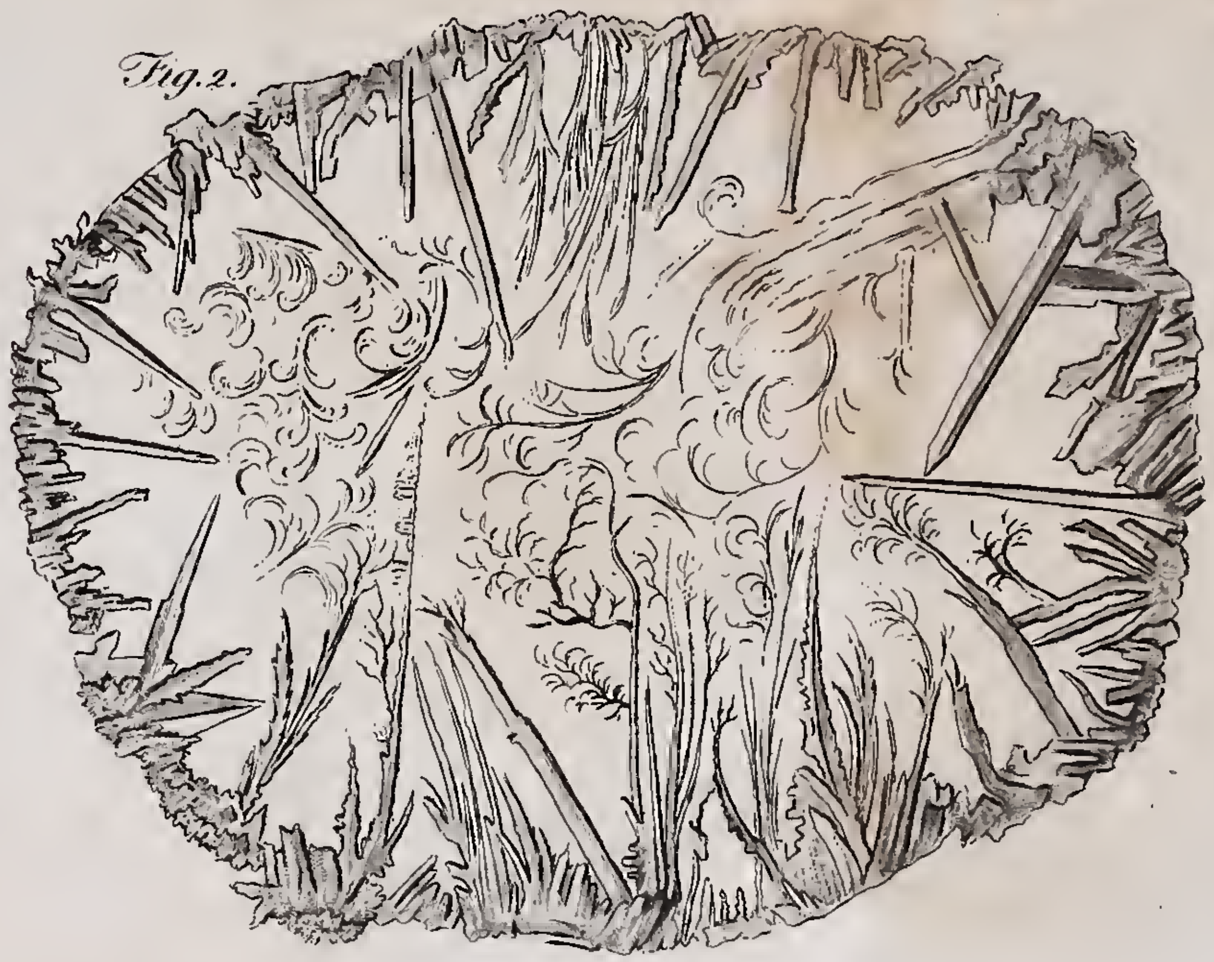


Fig. 2.



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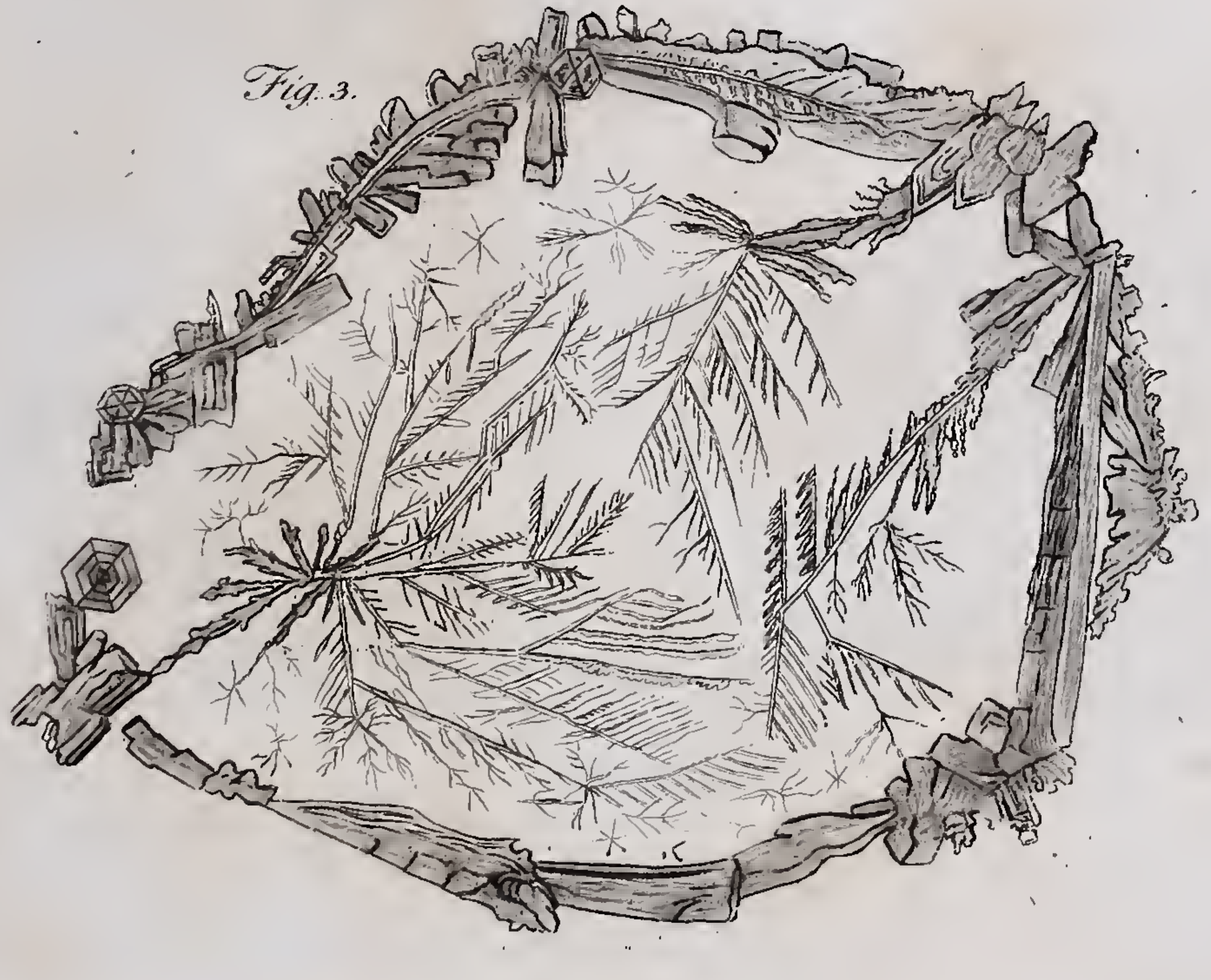
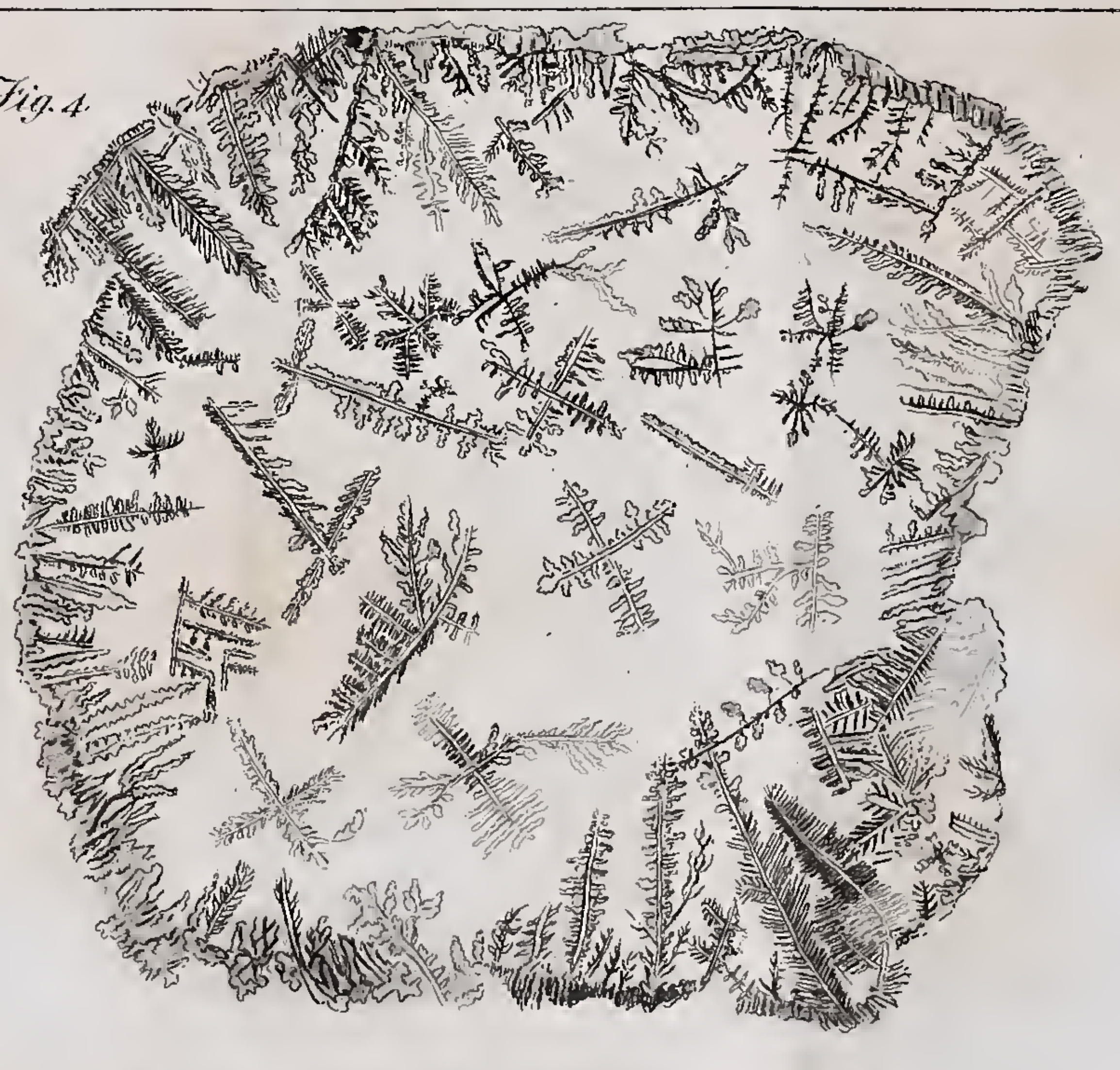


Fig. 4.



A

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| Single joint ſilver ſpectacles, with glaſſes | 0 | 15 | 0 |
| Ditto, with Brazil pebbles | 1 | 10 | 0 |
| Double joint ſteel ſpectacles, with glaſſes | 0 | 10 | 6 |
| Another ſort of ditto | 0 | 7 | 6 |
| Beſt ſingle-joint ſpectacles | 0 | 5 | 0 |
| Ditto, inferior frames | 0 | 3 | 6 |
| Noſe ſpectacles, mounted in ſilver | 0 | 7 | 0 |
| Ditto in tortoiſeſhell and ſilver | 0 | 4 | 0 |
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| Spectacles with ſhades | | | |
| Concave glaſſes in horn boxes, for ſhort-ſighted eyes | | | |
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| Ditto of an improved conſtruction | 1 | 1 | 0 |
| Concave and convex mirrors in frames, from 7s. 6d. to | 18 | 18 | 0 |

| | £. | s. | d. |
|---|---|---|---|
| Teleſcopes of various lengths, ſizes, and prices | | | |
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| Acromatic teleſcopes, with braſs drawers, which may be drawn out at once, and that ſhut up, conveniently for the pocket, from 1l. 11s. 6d. to | 13 | 13 | 0 |
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| A thirty inch acromatic teleſcope, with different eye pieces for terreſtrial and celeſtial objects, from 8l. 8s. to | 11 | 11 | 0 |
| Ditto with rack work | | | |
| An acromatic teleſcope, about three feet and an half long, with different eye-pieces | 18 | 18 | 0 |
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| Ditto in the Ptolemaic or common manner | 6 | 6 | 0 |
| Ditto, 12 inches in diameter, mounted in the beſt manner, from 5l. 5s. to | 6 | 16 | 6 |
| Ditto in the common manner | 3 | 3 | 0 |
| An armillary dialling ſphere | 40 | 0 | 0 |
| Manual orreries, from 1l. 1s. to | 3 | 13 | 6 |
| Planetarium, tellurian, and lunarium, from 18l. 18s. to | 31 | 10 | 0 |
| Adams's improved equatorial dial, or portable obſervatory, from 7l. 17s. 6d. to | 31 | 10 | 0 |
| Horizontal ſun dials, from 5s. to | 12 | 12 | 0 |
| Univerſal ring dials, from 7s. 6d. to | 3 | 3 | 0 |
| Tranſit inſtruments | | | |
| Aſtronomical quadrants, from 50l. to | 800 | 0 | 0 |

## Mathematical and Surveying Inſtruments.

| | | | |
|---|---|---|---|
| Caſes of drawing inſtruments, from 7s. 6d. to | 35 | 0 | 0 |
| Neat magazine caſes of inſtruments | 11 | 11 | 0 |
| Elliptical compaſſes | 4 | 4 | 0 |
| Beam compaſſes with diviſions, &c. | | | |
| Triangular compaſſes of a new conſtruction | | | |
| Adams's ſectoral, elliptical, and callipper compaſſes in one inſtrument, from 4l. 14s. 6d. to | 9 | 9 | 0 |
| Adams's protracting parallel rules, and univerſal plotting ſcale | | | |
| Protractors, ſectors, ſcales, parallel rules, &c. | | | |
| A new inſtrument for taking perſpective views, &c. | 12 | 12 | 0 |
| A ditto for aſcertaining points | 2 | 12 | 6 |
| Another inſtrument for taking views | 5 | 5 | 0 |
| Pantographer, from 2l. 2s. to | 6 | 6 | 0 |
| Plain tables, from 3l. 13s. 6d. to | 14 | 14 | 0 |
| Theodolites, from 4l. 4s. to | 31 | 10 | 0 |
| A neat portable theodolite | 8 | 18 | 6 |
| Adams's improved double theodolite, exceeding, for accuracy and utility, every former kind, from 12l. 12s. to | 31 | 10 | 0 |
| Meaſuring wheels, from 6l. 6s. to | 10 | 10 | 0 |
| Circumferenter, from 2l. 2s. to | 15 | 15 | 0 |

## Philoſophical Inſtruments.

| | £. | s. | d. |
|---|---|---|---|
| Improved electrical machines, from 3l. 13s. 6d. to | 40 | 0 | 0 |
| Electrical machine and apparatus, in a box, from 6l. 16s. 6d. to | 12 | 12 | 0 |
| Medical apparatus | 2 | 2 | 0 |
| Electrical machines, with a ſelected apparatus, in a box, from 7l. 7s. to | 31 | 10 | 0 |
| Batteries, and all other parts of an electrical apparatus | | | |
| Small ſingle-barrelled air pump | | | |
| Small double ditto | 4 | 14 | 6 |
| A large ditto | 6 | 16 | 6 |
| Table air pump | 10 | 10 | 0 |
| An improved air pump, ſuperior to Smeaton's conſtruction of the pump | | | |
| Apparatus to an air pump, from 4l. 4s. to | 30 | 0 | 0 |
| Barometers | 2 | 2 | 0 |
| Ditto | 2 | 12 | 6 |
| Barometers, thermometers, from 3l. 3s. to | 5 | 5 | 0 |
| Marine barometers | | | |
| Thermometers, in mahogany boxes, from 1l. 1s. to | 1 | 11 | 6 |
| Ditto with Reaumur and Farrenheit's ſcales | | | |
| Botanic thermometers | 0 | 18 | 0 |
| Thermometers for brewers, from 12s. to | 2 | 2 | 0 |
| Hygrometers, from 10s. 6d. to | 3 | 13 | 6 |
| The mechanic powers, compriſed in a ſmall neat form | 21 | 0 | 0 |
| Ditto, fitted up on a larger ſcale, with improvements | | | |
| An apparatus for making experiments on accelerated, retarded, and rotatory motion | | | |
| A mechanic apparatus fitted up for the purpoſe of inſtructing young people, &c. | 26 | 5 | 0 |
| A pneumatic apparatus, fitted up for the ſame purpoſe | 16 | 16 | 0 |
| An electrical apparatus, fitted up on the ſame plan | 7 | 7 | 0 |
| A magnetical apparatus, from 2l. 12s. 6d. to | 10 | 10 | 0 |
| Conductors for ſhips, to preſerve them from lightning | 5 | 5 | 0 |

* * *

## *ERRATA.*

Page 2, line 15, *for* animalculæ *read* animalcula.
8, — 22, *for* animalculæ *read* animalcula.
375, — 17, *for* eggs *read* chickens.

cl. 5/48